INTERMOUNTAIN STATION
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Investigative Progress
Intermountain Region

REPORT OF THE

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION

AND

REGIONAL INVESTIGATIVE COMMITTEE

INTERMOUNTAIN REGION

1931-1932

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REGIONAL INVESTIGATIVE

COMMITTEE MEETING

1932

Regional Investigative Committee Meeting

The regular annual meeting of the Regional Investigative Committee of the Forest Service to consider the progress during the past year and plans for the F.Y. 1933 in forest, range, erosion-streamflow and biological research in the Intermountain Region was held in the Regional Office, Ogden, Utah, on February 23 and 24. At this meeting there was reported and discussed, progress and plans of the Intermountain Forest and Range Experiment Station and the administrative investigative projects being carried by the Regional organization of the Forest Service.

This report reviews briefly the different projects presented and discussed at the meeting and embodies the annual report of the Station as well as the report on projects being handled by the administrative organization.

Those in Attendance at the Investigative Committee Meeting

Regional Office

R. H. Rutledge - Regional Forester
C. B. Morse - Forest Management
E. C. Sanford - " "
Ernest Winkler - Range Management
Orange Olsen - " "
A. R. Standing - " "
C. N. Woods - Operation
Dana Parkinson - Public Relations

Intermountain Forest & Range Experiment Station

C. L. Forsling
George Stewart
E. W. Nelson
G. W. Craddock
S. S. Hutchings
Milo H. Deming
Chas. A. Connaughton
Kenneth Pearse
Raymond Price

National Forests

Chas. DeMoisy	- Forest Supervisor, Uinta N.F.
C. B. Arentson	- " " Cache N.F.
Blaine Betenson	- Asst. For. " Wasatch N.F.

Utah State Agricultural College

T. G. Taylor	- Professor of Forestry
R. J. Becraft	- Professor of Range Management
R. W. Bailey	- Professor of Geology
E. J. Maynard	- Professor of Animal Husbandry
Paul M. Dunn	- Extension Forester

Other Representatives

C. M. Genaux	- University of Idaho
T. L. Martin	- Brigham Young University
V. M. Tanner	- " " "
B. F. Harrison	- " " "
W. P. Cottam	- University of Utah
Dilworth Walker	- " " "
Dr. Geo. R. Hill	- American Smelting & Refining Co.
Geo. F. Stallings	- Pres., Utah Farm Bureau
T. B. Murray	- U.S. Biological Survey, Boise, Idaho
R. Scott Zimmerman	- " " " Salt Lake City, Utah
J. F. Mendenhall	- Utah State Land Board
J. R. Parrish	- " " " "

The Investigative Committee meeting of 1932 emphasizes the inadequacy of handling the full research program in the region in the short period of two days. Owing to necessary economy and time, a two-day, instead of a three-day meeting as has been customary for the last several years, was held. There is always a keen demand for a presentation and discussion of results each year, and especially when only a two-day meeting is held so much time is taken up in the discussion of results that there is little opportunity for a thorough consideration of plans. It appears advisable, and therefore is proposed, that a three-day meeting be held in the future, two days to be devoted to presentation and discussion of results and the third day to be a semi-executive session in which plans only would be considered. It is

suggested also that a preliminary one-day meeting be held at Boise or some other appropriate meeting place in Idaho for the consideration of work being done in the northern part of the region. The Ogden meeting is seldom successful in having many representatives outside the Service from Idaho, owing chiefly to the travel expenses involved. This means the Station is losing the opportunity to keep posted the several groups interested in the work and to receive the benefit of the suggestions of these people in the planning of the Station program.

Research Policy

One feature of the Investigative Committee meeting was a discussion of research policy. The various points raised are presented more for the purpose of provoking thought and discussion rather than to fully answer the questions raised.

One idea advanced was that in times such as the present economic depression, when expenditures are being curtailed and when governmental employees are being required more scrupulously than ever to give the best accounting for every dollar, it is urgent that research expenditures be devoted rather largely to study of such problems as will be directly useful to the public in meeting the problems of the day. Some of the investigations are concentrated on problems which seem more or less theoretical or abstract and do not afford much concrete usable information to private citizens engaged in range or forest occupations or industries. Other investigations are so long-drawn out that by the time the results are obtained the purpose in initiating the research is forgotten. Still other problems being "researched" ran off on tangents to the real needs rather than aiming directly at the solution needed.

Then, it was said, research workers tend to be extravagantly "exact" and refused to release information unless the experiment had been refined and the data re-digested and re-distilled until it was the double-rectified quintessence of lily-white "truth." By the time the digestion and distillation of data and the rectification and bleaching of the conclusions had been made all sufficiently purified and sanitary for the "public," either their usefulness had been "cooked" out, or another economic era had come around. Of course, this is a rather extreme statement but it does exemplify one of the trends in research, opined one who thought the path from an experimental plot to a stockman could be infinitely straightened and shortened. It was clear that the author of the opinion on over-purification of research was expressing his own opinion only in part, but was trying to show that he had heard some such resemblance of opinion from private interests. He recognized the necessity of a good program but felt that there was considerable opportunity to make projects shorter and capable of serving more directly the "real" needs as opposed to the "theoretical" needs of the individual operator.

Still another theory advanced for discussion was that through the application of results of research, administrative management plans are becoming too technical and detailed for good economical practice. Even part of the flare-back from certain interests with regard to National Forest administration being too rigid and too impractical, may be the result of too much refinement.

An analysis of the projects carried by the Intermountain Station will not justify the full sweep of criticism. However, there may be room for some improvements. The studies as now conducted are largely empirical with an economic answer at the end. No question is more frequently asked by private ranchers than how to obtain seed of desirable forage plants and how to reseed depleted lands with them. Whether or not an area that has lost its best soil can be successfully reseeded to desirable forage species is a problem of today. Knowing just how much a drought year such as 1931 may influence forage supply is urgent. The rapidity, or the slowness with which forages revegetate themselves under protection and under controlled grazing is fundamental in encouraging owners to protect their private ranges as well as a guide in handling public ranges. It is a timely matter to know how to stop further soil losses, and how to prevent floods like those of 1930 in Utah. Rate of snow melting for example is information needed for management to insure favorable streamflow. A methods of cutting study of ponderosa pine carried on for a sufficient period will show what sacrifices may be made in timber sales in times of economic depression. These and many other studies all have an economic purpose.

Station projects must be selected on the basis of urgency from the standpoint of a period of years. It is true emphasis on urgency will vary from time to time and research must be careful to select for use of the funds available, the problems of most importance in the long run. To shift emphasis from year to year would make it impossible to solve many of the more fundamental problems. However, there is a need for a sort of "flying squadron" in research to help meet some of the day to day problems.

Such work undoubtedly would make a favorable impression on the public. It could be accomplished by maintenance of a kind of flexibility in the use of part of each station's funds which would permit the Director to use certain funds on what in his judgment, are important problems of the day and thus not tie all funds up in a rigid program of prescribed projects.

With regard to time and accuracy in research, tests may be too long or too short. The continuation of an experiment largely for theoretical reasons or to satisfy some whim of the investigator, after it has served the "practical" end for which it was begun can not be justified. A good investigator, on the other hand, is woefully afraid when he is permitted to have nothing but short tests. They "burn his fingers" too many times and confidence in his integrity is soon lost. He knows nature often does not give her answers in a few weeks or in one or two seasons. It is almost impossible adequately to study such problems as erosion even in a few seasons. It may take years for soil to be lost and another series of years for plants to become adjusted to the new conditions, and it will certainly require many years to build up a high forage production where the good soil had been removed.

The most productive research program is a combination of short and of long-time projects properly distributed. Long-time projects should be maintained, but handled in a manner that they were made to yield annual contributions to the fullest extent possible, and at the same time become cumulative for a number of years until a major problem is really solved. Short-time tests are being conducted when this can effectively be done.

A properly balanced program also attacks economic problems directly but does not overlook the value, from a scientific point of view nor from a fundamental economic point of view, of certain principles in plant ecology, plant physiology, soil fertility, etc. The public wishes and immediate needs must be recognized, but it is also necessary to keep in mind that the wishes of the more intelligent stockmen and timbermen are based more and more on what is good for the permanent welfare of the industry as a whole. They want immediate results, of course, but they also want to see established the foundational principles of a secure, non-speculative future development.

The criticism that research results are responsible for a too technical an administration is true in part only, if at all. If at all it is largely because of too little rather than too much research. Problems have not been studied thoroughly enough to know the latitude for the application of a given result. Hence there may be the possibility that the Forest Service is hewing so closely to a given line that under certain circumstances the practices are too rigid for the needs of certain emergency economic situations. That, however, should not condemn research. Perhaps there is a need for administration and research to get together for a consideration of the degree of latitude that may be permissible in certain management principles in order to help meet acute economic situations and the "practical" needs of the public.

REPORT OF THE

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Station Personnel

C. L. Forsling - Director.

Walter E. Mann)
Marguerite A. Israelson) - Clerks
Teresa V. Cordell)

Forest Management

Methods of cutting ponderosa pine:

Chas. A. Connaughton
_____ (vacancy)

Range Management

Utah Plateau Summer Range:

E. W. Nelson
Raymond Price

Artificial Reseeding:

E. W. Nelson
Raymond Price

(Sweet clover investigations in cooperation with Bureau of Plant Industry, Office of Forage Crops, Russell A. Oakley, in charge, L. W. Kephart.)

Sagebrush-bunchgrass Range (Spring-Fall):

George Stewart
G. D. Pickford

(Upper Snake River Plains in cooperation with Bureau of Animal Industry, U. S. Sheep Experiment Station, Dubois, Idaho, J. M. Cooper, Supt. in charge.)

Desert Shrub (semidesert winter ranges):

George Stewart
Selar S. Hutchings

Bunchgrass on Granitic Soils:

Geo. W. Craddock, Jr.
Kenneth Pearse

Erosion and Streamflow

C. L. Forsling - In Charge.

Bunchgrass type, granitic soils, Idaho:

Geo. W. Craddock, Jr.
Kenneth Pearse

Utah Flood and Erosion Survey:

Milo H. Deming

(In cooperation with Utah State Land Board, J. F. Mendenhall, executive secretary, and Utah State Agricultural Experiment Station, P. V. Cardon, Director.)

Colorado River Erosion Survey:

Milo H. Deming

(In cooperation with Region 2, Allen S. Peck, Regional Forester, and Jay Higgins, Forest Supervisor.)

Biological Investigations in cooperation with U. S. Biological Survey:

_____(vacant)

Personnel Changes

Personnel changes are always disrupting to the program of a station; nevertheless it is realized that each station must contribute its share to the development of other stations and to other lines of work. During the year L. F. Watts, senior silviculturist and assistant director, was transferred to the directorship of the enlarged Northern Rocky Mountain Forest and Range Experiment Station. F. G. Renner, associate range examiner, in charge of the erosion and streamflow and range management on bunchgrass type on granitic soils, was transferred to the newly organized section of range management of the California Forest Experiment Station. S. B. Locke, associate biologist (assigned by the Biological Survey) resigned to accept a position as director of conservation of the Izaak Walton League. George W. Craddock, Jr., associate range examiner, was transferred from the section of range management to fill the vacancy left by Renner. Selar S. Hutchings, junior range examiner, was transferred from Region 4 to the station and assigned to the desert shrub project. Raymond Price was appointed junior range examiner from the Civil Service eligible list and assigned to the Great Basin Branch Station. Milo H. Deming, former assistant forest supervisor of the Wyoming N. F. was transferred to the station and assigned to the Colorado River erosion and Utah erosion and flood surveys. E. L. Mowats has been transferred from the Lake States Forest Experiment Station and will report following termination of leave without pay to attend school on June 1, and will be assigned to the forest management section. Teresa V. Cordell, clerk, was

transferred from Region 8 and assigned to the clerical section. The station is endeavoring to find a suitable statistical clerk or junior statistician. The following field assistants were employed during the year: A. F. Dodge, Iowa State College and Joe Pechanec, Univ. of Idaho, in forest management; E. R. Crook, Michigan State, erosion and streamflow; Geo. M. Fisher, Univ. of Idaho, E. C. Crafts, Univ. of Michigan, Miss Sylvia Griswold, Univ. of Chicago, and Dr. E. C. McCarty, Riverside Junior College, California, summer range; in addition, assistant professors Floyd Otter and Lyter E. Spence were assigned by the Forest School of the University of Idaho to forest management and bunchgrass type on granitic soils and erosion and streamflow projects, respectively. The region aided in the detail of two junior foresters and one ranger (from the junior range examiner eligible list) for compilation work during the winter of 1931-1932. This made possible an arrangement for detail to Washington of H. M. Shank of the Regional office to make an analysis of past fires on the eight so-called fire forests of the region.

New Work

During the year there was added one new project. An additional allotment of $9,500 was made available for the study of erosion and streamflow in the Great Basin. During the first year this money is being used for a flood-erosion survey in Utah and an erosion survey on the upper Colorado River watershed, the Utah flood and erosion survey being carried on in cooperation with the Utah State Land Board and Utah State Agricultural Experiment Station. The State Land Board is paying the expenses of a

geologist and a professor of range management assigned from the Utah State Agricultural College. A survey is being made of the 30 or more places in the state where severe floods occurred during 1930. The State Land Board is interested in securing information to aid them in planning a constructive watershed policy for the state.

The Colorado River survey is an attempt to ascertain the character and extent of accelerated erosion in the Colorado River watershed and its influence on development of the stream on range lands and on other agricultural and industrial development in the Colorado River basin.

Following the completion of the survey the first year, the funds will be used in the study of the more important aspects of the problems of erosion and streamflow in the Great Basin.

Meetings

The regular biennial field day was held at the Great Basin Branch Station on August 14 and 15. This was attended by over 200 stockmen and others interested in the work of the Station. This meeting ranked with those held in the past several years and was considered successful in every way. These meetings are being held where concrete results of range and erosion-streamflow research can be demonstrated and are proving of immense importance in stimulating interest in land management in Utah, and to a lesser extent throughout the Intermountain region and the West. One full day of the 1931 meeting was devoted to reviewing and discussing the results of research in the field. This was followed by an evening campfire meeting which was addressed by prominent visitors, including Senator Reed Smoot of Utah. The second day, as has been the custom during

the three preceding field days, was turned over to the stockmen and visitors for a discussion of such range management problems as they wished to consider.

A meeting on August 17 to 20 at the Great Basin Branch Station was held under the auspices of the Ecological Society of America to consider range research methods. This meeting was attended by 46 people and there were represented three of the forest and range experiment stations, the Washington office of Research, three of the national forest regions, the U. S. Indian Service, the U. S. Bureau of Animal Industry, the U. S. Biological Survey and seven of the state universities or agricultural colleges. This was the first major get-together of people interested in methods of range research. All together it was a very profitable meeting. Recommendation was made that another meeting be held in 1933 in some portion of the West.

Experimental Forests and Ranges

Two areas were tentatively selected for a desert shrub experimental range and recommendations submitted that one of these be selected and set aside. Two areas were tentatively selected for an experimental ponderosa pine forest. Final recommendation for one of these is being delayed pending the outcome of land exchanges which would make possible a better rounding out of one of the areas for an experimental forest.

FOREST MANAGEMENT (Silvical Research)

Methods of Cutting Ponderosa Pine

Silvical investigations were initiated by the Intermountain Station in the fiscal year 1931. The work now consists of one major project - methods of cutting ponderosa pine, which includes also two subprojects, namely, a study of the influence of forest cover as may result from different methods of cutting, on snow storage and rate of snow recession in the spring and a study in cooperation with the University Of Idaho, of plant succession following different methods of cutting and its effect on natural reproduction. In addition the Station is carrying two minor special jobs consisting of assisting Region 4 in making an analysis of past fire records and in securing better practices in administrative forest research plots.

The list and history of established permanent ponderosa pine sample plots are as follows:

Three five-acre cut-over plots on Carpenter Creek of the South Fork of the Payette River, Payette N.F., established and cut over in 1913.

One five-acre cut-over plot on Little Ditch Creek of the North Fork of the Salmon River, Salmon N.F., established and cutover in 1909.

Twelve five-acre virgin stand plots on Big Pine Creek of the South Fork of the Payette River, Payette N.F., established in 1914 and 1915.

Four five-acre virgin stand plots on Poorman Creek of the South Fork of the Payette River, Payette N.F., established in 1913.

Progress during 1931

(1) The four methods of cutting ponderosa pine plots established between 1909 and 1913 were remeasured for the third time and the data are now summarized and awaiting final analysis for a report on 20 years growth following cutting. These data are to be analyzed by the mechanical system and at present are coded on 80-column code sheets. The records include the individual tree history, and board and cubic volumes and basal area at each time of measurement. The preliminary coding has suggested various sorts by the Hollerith machines and the analysis will make it possible to determine growth and survival as influenced by individual tree characteristics.

(2) The sixteen virgin plots in ponderosa pine established in 1913 were remeasured for the second time and the records have been fully coded for mechanical analysis to furnish information on character and behavior of virgin stands over a period of 18 years.

(3) The selection of an experimental ponderosa pine forest has been narrowed down to one particularly desirable area in Boise Basin. Effort is now being made to complete arrangements with the Regional office and private owners of adjacent lands in preparation for final recommendations.

(4) The location of the study of the relation of ground and crown cover to storage and melting of snow was changed in the spring of 1931 from Boise Basin to the vicinity of McCall, Idaho where better field conditions were available. Five 2½-acre semi-permanent plots were located on which detailed records were obtained of the amount of snow that accumulated during the winter and of the time and rate of melting in the

spring. In addition several supplemental snow survey courses were observed and measured from time to time. The snow and melting records were supplemented during the melting period with observations on precipitation, air and soil temperature, wind velocity, and soil moisture. The five plots embrace the following conditions of crown and ground cover: a bare site, a heavy cover of sagebrush, a stand of 30-year old reproduction, a typical overmature open stand of ponderosa pine and an overmature ponderosa pine stand with a heavy understory of advanced reproduction.

The relative amounts of water storage in the snow on the plots at the time of maximum storage on March 30, considering the greatest cover of 10 inches of water on the sagebrush plot as 100 per cent, were as follows: bare ground 99.5 per cent; young growth 87.5 per cent; mature-timber-without-advanced-reproduction 72.5 per cent; and mature-timber-with-advanced-reproduction 63.5 per cent. The sagebrush and bare plots became bare of snow first or 25 days after the date of maximum moisture supply. The young growth plot became bare four days later, the mature timber plot six days later and the mature-timber-with-advanced-reproduction ten days later. In other words, it took a third longer for the timber-with-advanced-reproduction plot to become bare, approximately 22 per cent of the original maximum moisture supply remaining on the timber-with-advanced-reproduction plot on the date the sagebrush and bare plots had lost all their snow. The weather observations show higher wind velocities, more hour degrees of melting temperatures and more direct sunshine on the snow on the bare and sagebrush plots. These results are similar to those obtained in Boise Basin

in 1930. Records of the disposition of 36 per cent of the water deficiency on the mature timber-advanced reproduction plot were not obtained but it is considered that at least a large part was evaporation loss from snow intercepted by the foliage and branches of the trees. No record was obtained of the greater loss of moisture during the melting period by evaporation from snow on the brush and bare plots. In both years there was subnormal snowfall.

(5) The study of plant succession in relation to natural reproduction under varying methods of cutting ponderosa pine was initiated under an informal cooperative arrangement with the University of Idaho. Observations were made on cut-over stands of different ages and the presence of reproduction in relation to the subordinate vegetation was noted with reference to the type of cutting, fire and grazing. The short duration of the project made only preliminary minor investigations possible in addition to developing suitable methods for future procedure.

(6) As special jobs further cooperation was furnished the Regional office in the statistical analysis of their past fire records. At present the final sorting by the Hollerith machines of these data is being completed in Washington and compilation of a final report will complete the study.

Cooperation was also furnished the Regional office in standardization of their administrative plot work and assistance was furnished in the remeasurement of two ponderosa pine plots, two lodgepole pine plots and in the preparation of a progress report on six lodgepole pine method of cutting plots.

Plans Fiscal Year 1933

1. Remeasurement of snow storage and melting in relation to quality of crown and ground cover on the snow recession plots at McCall, Idaho. The field work will be done in the present fiscal year and the data will be compiled subsequently.

2. If commercial operations will be going and other circumstances will permit, it is planned to establish a series of plots embracing the following methods of cutting: (1) An "economic" selection quality cut or a high grading of the stand after the policies of some private operators; (2) a heavy selection cut according to generally accepted Forest Service marking practice; and (3) an unusually heavy diameter limit cut that would remove practically every merchantable log with the exception of a few in low quality thrifty trees. Detailed plots of 5 to 10 acres in size surrounded with a suitable isolation strip involving not less than a total of 40 acres to be cut over, will be established for each method of cutting.

If the necessary cooperation can be secured from the Regional office and the private operator, a cost of logging study for each of these different methods should be made. A logging cost study is particularly needed in this locality at this time due to the changing of the past cutting practices of the private concerns in an attempt to meet the present economic situation. Obviously the entire study is dependent upon whether or not there will be any cutting operations at all next year. Furthermore certain cooperation is absolutely necessary if the logging cost phase is carried out.

3. The plant succession in relation to natural reproduction study in cooperation with the University of Idaho, will be carried forward on various national forests and private cutting areas under conditions affected by different degrees of grazing and fire. The University will assign a man to this study.

4. Occasional assistance will be given the Regional office in the standardization of remeasurement and establishment of administrative plots.

5. Advantage of every opportunity will be taken to work out the difficulties relating to the establishment of the experimental forest and such detailed cruising, planning of station and other work as can will be done.

6. The analysis of the data for the four five-acre plots in cut-over ponderosa pine will be completed for the preparation of a progress report.

7. The analysis of growth on the sixteen five-acre virgin ponderosa pine plots will be carried forward for the preparation of a report.

8. It is a good many years since the working plan for the methods of cutting project was prepared. A revision is in process of preparation including the subdivisions of the project. It is aimed to complete this plan during the year.

9. Owing to the contingencies involved in the establishment of the new methods of cutting plots the following work is proposed as a substitute if such becomes necessary.

(a) Establish two new methods of cutting plots on private land cut-over late in the fall of 1931 or spring of 1932 under a typical high grading method.

(b) Make an intensive study by cruise and semi-permanent plot observations on national forest and private cut-over lands on granitic soils with special regard to the reserve stand, methods of brush disposal, natural reproduction, growth since cutting and degree of grazing, as a supplement to the methods of cutting project.

(c) Make a fire-damage and natural reproduction study on the large areas of ponderosa pine land burned over during the summer of 1931. These areas include both cut-over and virgin timber and were burned with varying degrees of intensities thus affording an excellent opportunity to study damage, loss and future behavior with special reference to natural reproduction in a locality especially suited for the work. Numerous burns of varying ages can also be found in close proximity to supplement the study of the disastrous fires of 1931.

(d) As early as 1860 ponderosa pine has been cut more or less extensively in Boise Basin. Much of this area was burned over and parts were totally denuded following cutting by placer mining which removed the top soil, leaving unfavorable conditions for tree growth. Cutting operations have been in progress most of the time up to date. Many of these areas now have a surprisingly good stand of ponderosa pine reproduction and much information on reproduction, restocking and growth following cutting, etc. could be obtained here. It is desirable, therefore, to ascertain as much information as is possible regarding the source of seed, per cent restocking, growth, probable future of the stand and site conditions influencing such a remarkable stand of reproduction.

RANGE MANAGEMENT

Summer Range - Wasatch Plateau (Great Basin Branch)

Work on this project was started in 1912 and has been carried continuously since that time. Numerous phases of the project have been completed and results published and new phases have subsequently been undertaken from time to time. The field work in some of the latter has been completed and data are awaiting analysis and publication. Still others are being carried forward.

The subprojects for which accumulation of field data is practically completed and now awaiting analysis, are as follows:

1. The influence of season, frequency, and degree of harvesting on the productivity, revegetation, and vigor of range forage plants. Two grasses and one weed were harvested under 16 systems of treatment from 1923 to 1930, inclusive. Six systems previously investigated under clipping methods were carried into the field under actual grazing conditions in paddocks and were continued from 1923 to 1930.

2. A study of the proper degree of utilization of range lands. A pasture was construced on the highest summer range and a study was started in 1925. The pasture has been grazed by a small herd of cattle each summer since 1925. Eleven permanent plots and quadrats have been handled in a manner to obtain varying degrees of utilization of the important range plants and to measure the influence on the vegetation. A re-examination of the quadrats and major plots and a recheck by grazing survey of the entire pasture in 1932 will complete the field work in this project.

3. Vegetational readiness and the length of the grazing season on mountain range lands. Since 1925 systematic observations have been made

of 32 selected important range species situated at various elevations to determine the variation and its causes in plant growth and development from year to year. This includes growth records of the individual plants from beginning of growth in the early spring until covered with snow in the fall. The volume of data is so great that it will be necessary to make analysis by the mechanical system.

4. The role of seed habits in range plants in natural revegetation. The seed habits have been observed, seed has been collected, and germination of seeds has been studied under 17 conditions for 55 of the important range plants on the Wasatch Plateau. The field work is completed and results are being analyzed.

The subdivisions of the project in which field observations are being continued, several of which have been under way a sufficient time to warrant the publication of a progress report, are as follows:

1. The effect of climate on plant growth. Records of the more important climatic factors have been kept during the growing season continuously since 1914 in three vegetative zones on the Wasatch Plateau. Since 1924 forage yield data have been obtained on from five to eight yield plots and observations made on the rate of growth of 12 important species for correlation with climate. Field work in the project will be continued, but sufficient years records are available to warrant compilation and preparation of a progress report for publication at the earliest possible date.

2. Range improvement and maintenance by natural revegetation of principal forage species. Permanent quadrats, major plots, and intensively

mapped areas have been established beginning with 1914, until at present there are 72 quadrats, 69 major plots, and five intensively typed areas. These include ungrazed and grazed sample areas under various methods of management under all degrees of range and soil depletion in each of the three major vegetation zones of the Wasatch Plateau. These experimental areas will show plant succession and other vegetational changes for all of the conditions involved. These sample areas should be maintained indefinitely, but a progress report should be compiled as soon as possible.

3. The effect of intensity and frequency of harvesting on important browse plants. Birchleaf mahogany and snowberry are being clipped at the close of the growing season (1) to remove all the current season's growth, (2) to leave one inch of the new growth, and (3) to leave two inches of the new growth. Snowberry is also being clipped in July as well as at the close of the growing season. The annual yield from each method of treatment is being determined for comparative purposes. Yield data have been obtained for five years. The treatment should be continued.

4. The effect of various frequencies and degrees of cropping upon the carbohydrate metabolism of important range plants. This is a cooperative project with Dr. E. C. McCarty of Riverside Junior College. He will work as a field assistant during the summer season and make the chemical analysis at the Riverside College during the winter months. A preliminary study was made in 1931. It will be continued with a clipped series of plants of many-flowered brome, violet wheatgrass and geranium and grazed series of other plants during 1932, 1933 and 1934.

Progress during 1931

Climate and plant growth. The range forage crop of 1931 was the poorest it has been in the eight years that yield records have been obtained, production on the average being 40 per cent below the eight-year average. The total precipitation for the summer growing season was 53 per cent below the 17-year average and was the driest on record in the oakbrush and aspen-fir zones. Climatic conditions in the main have been below average since about 1923. Several years, notably 1925, 1927 and 1929, were somewhat above, but the rest were unfavorable in one way or another. Protected range areas have held up fairly well. But grazed national forest ranges adjacent to the Experiment Station plots, while they have furnished their full complement of feed to permitted livestock, are showing the affects of drought and grazing. These ranges were holding their own and were actually improving until about 1928 or 1929. Since that time they have begun to decline and in places are reaching a critical condition. Erosion, at one time fairly well under control, is increasing again and unless more favorable climatic conditions obtain the next season or two serious injury seems unavoidable.

Natural revegetation. A series of permanently protected and grazed plots in the oak zone, of which all except the protected plot have been grazed to approximately the same degree at the close of the season, show the following results during the period 1925 to 1931:

Where grazing started in the spring 10 to 14 days before vegetational readiness there was a slight decline in total density. However,

sagebrush more than doubled in density and the grasses and more palatable weeds lost as much density as the sagebrush gained. On the plot where grazing did not begin until vegetational readiness there was a 50 per cent increase in total density. The chief gain was in grasses and sagebrush, both of which practically doubled in density during the six-year period. On a plot on which grazing was deferred until seed maturity each year there was a gain in total density of approximately 80 per cent. Shrubs, mostly sagebrush, almost trebled in amount and grasses increased approximately 200 per cent. The plot protected from grazing yearlong and which had a density one-half to twice more than the grazed plots to begin with, increased only approximately 18 per cent in density during the period. Grasses increased slightly more than 10 per cent and shrubs gained 25 per cent. The grazing capacity of the plot on which grazing began before vegetational readiness declined 25 per cent, the one grazed seasonlong after vegetational readiness increased 35 per cent to 40 per cent, and the plot deferred until seed maturity each year increased approximately 73 per cent. The area protected from grazing increased 20 per cent in forage productivity.

Whether the stands of niggerhead (Rudbeckia occidentalis) are increasing in density and area, and if so to what extent any increase may be due to overgrazing, is a matter of considerable importance on mountain ranges. This species frequently occupies large areas on some of the best sites. Over a 7-year period the increase in number of niggerhead plants was 18 per cent greater on a grazed plot located several hundred feet away from a heavy stand of niggerhead as compared to an ungrazed plot located at the former edge of the invasion. There was a 30 per cent greater increase

of grasses on the ungrazed plot than on the grazed plot. The grazed area was conservatively utilized by cattle each season. Although there was considerable increase on both plots, the increase of niggerhead was proportionately greater on the grazed area. There appeared to be an inverse relation between increase in niggerhead and amount of precipitation. Increase in niggerhead increased inversely with the density of the grasses.

The past season was the regular year for remapping all quadrats, major plots, and intensively mapped areas. This was completed in the oak zone, but the drought prevented completing the work in the higher zones.

Two major plots each 33 x 33 feet in size, one grazed and the other closed to grazing, were established in 1925 in the oakbrush type on a site dominated by birchleaf mahogany (Cercocarpus montanus). In the following year two similar plots 16 x 48 feet in size, were established at the upper edge of the oak type in a heavy stand of snowberry (Symphoricarpos oreophilus) and sagebrush (Artemisia tridentata). The shrubs on the four plots were mapped in 1926 and remapped in 1931. The following table shows the per cent increase or decrease of the density, on the basis of crown spread, of the shrub species on the grazed and ungrazed plots in 1931 as compared to 1926:

Species	Ungrazed Plot	Grazed Plot
	%	%
Birchleaf Mahogany Area		
Cercocarpos montanus	+56	-20
Quercus gambelii	+39	- 9
Symphoricarpos oreophilus	+12	-32
Total density	+54	-19
Snowberry-sagebrush Area		
Symphoricarpos oreophilus	+ 153	+52
Artemisia tridentata	+ 6	+64
Sambucus caerulea	+ 247	-11
Total density	+ 75	+44

The increase on the ungrazed plots in spite of none too favorable climatic conditions, is undoubtedly due to release from the grazing pressure that formerly prevailed. The extent of the smaller gains or net losses on the grazed plots chargeable to unfavorable climate and the extent chargeable to overgrazing has not been determined but it is evident the combination has been unfavorable to all the shrubs except snowberry and sagebrush.

Plans for Fiscal Year 1933

Essential recurrent field work in the climate and plant growth, natural revegetation, effect of intensity and frequency of harvesting on shrubs, and carbohydrate metabolism projects and final field observations in the utilization study is all that will be carried through the season of 1932. Even this will be cut to the absolute minimum required. The remainder of the time available will be applied to compilation and analysis in the projects for which field data are now completed. A junior range examiner with field assistants will be able to handle all of the current field work thus making available all of the time of others assigned to the project for compilation.

Bunchgrass on Granitic Soils

This project was started in 1930 in conjunction with the erosion-streamflow project on the same watershed. The studies thus far have been concerned chiefly with detailed measurements of vegetation on grazed and ungrazed plots, preliminary analyses of soil profiles, and of available climatic records. The vegetative studies have been made on representative range areas varying in elevation from 3200 feet to 7900 feet. The studies are concentrated on eleven areas fenced against grazing in 1930 and 1931, varying in size from approximately 0.1 acre to 200 acres, and on comparable grazed range in the vicinity of the fenced areas. The vegetative data have been obtained by the sample plot and quadrat methods on fifty-three 5x5 meter major plots and fifty-three 1-meter quadrats inside the stock exclosures and forty-seven major plots and forty-two quadrats on grazed range. The soil studies have involved the physical and chemical analysis of 170 samples taken on selected sites over the watershed. The analysis of the climatic factors has been based on records obtained at U. S. Weather Bureau Stations on and in the vicinity of the Boise Forest.

As a result of the data obtained, the bunchgrass type on the watershed has been classified into three distinct phases, based upon the dominant plant species and soil. The most luxuriant of these phases is characterized by thrifty perennial weeds and grasses, chiefly Agropyron spicatum, Balsamorhiza sagittata and Lupinus comatus and is found on a few very limited areas which have not been grazed abusively. Analyses indicate that the soil on which this type is developed has a more friable

texture, a higher content of organic matter, a greater water-holding capacity, and more abundant plant food than has any other soil in the bunchgrass type on the watershed. That the type was once much more widespread than at present is suggested by the occurrence of isolated patches of the species characteristic of the type at all elevations, and on all aspects and degrees of slope.

The second phase, into which falls most of the bunchgrass type found on the area, is characterized by less thrifty, coarse rooted perennial weeds and grasses with annual species making up a large part of the stand. This association of plants appears to be typical of the more recently overgrazed range that has lost much of its best surface soil in recent years and is found at all elevations and on all aspects and degrees of slope. The soil in this type is exceptionally low in water-holding capacity, in plant nutrients, and the texture is generally coarse. Frequent relicts of the bunchgrass type indicate a rather close relationship between the two, it being suggested that overgrazing may gradually transform the bunchgrass association into the less palatable and less luxuriant perennial weed-grass stage.

The third phase appears to be associated with overgrazing and loss of original plants and surface soil that occurred 30 to 50 years ago and occurs more commonly on the dry south facing slopes at the lower elevations. The vegetation is characterized by downy brome grass (Bromus tectorum) and other annual grasses and weeds, and but few perennial species occur. All of the species make a rapid growth in the early spring and by June have

produced seed, are drying up, are useless as forage, constitute a fire hazard, and are of medium value in soil protection if not burned over. The soil supporting this type is usually raw, coarse and low in plant food. A few analyses show that due apparently to the addition to the soil of litter from the decadent annual plants, the water-holding capacity is usually somewhat greater than in the preceding phase although it does not approach that of the bunchgrass type. The type is characteristic of the very seriously depleted ranges of the region and apparently succeeds the previous type if this is subjected to overgrazing.

At one time the bunchgrass type undoubtedly was well distributed over the watershed. The present condition of the vegetation is apparently due to overgrazing which has caused the bunchgrass to give way to other less thrifty perennial weeds and grasses, which in turn, with continued over use, are largely succeeded by annual plants of inferior forage value. Along with these changes have gone a correlated series of soil changes resulting in a loss of fertility and of water-holding capacity, and in a less desirable soil structure.

Plans for Fiscal Year 1933

The remeasurement of protected plots in different elevational zones for the purpose of correlating plant growth from year to year with annual fluctuations of climate. This phase of the project is recurrent in nature and as soon as physical factor and climatological stations can be permanently established, the quadrat and major plot data will be supplemented with phenological observations.

An investigation of the root systems of important herbaceous and shrubby species. These studies will be aimed at determining the adaptability of species to different conditions of site and the relative soil binding and water retention qualities of different root systems. Additional soil samples may be taken in connection with these phases of the study.

The establishment of a few new plots and quadrats within and adjacent to newly constructed exclosures.

Management Sagebrush-Wheatgrass (Spring-Fall) Range

As a result of exploratory trips thus far, three principal divisions of the sagebrush-wheatgrass (spring-fall) ranges have been recognized.

A. Sagebrush-wheatgrass ranges of Utah. These are chiefly foothill lands in which bunchgrass probably outranked the sagebrush but use has greatly reduced the grass and the sage has increased except where there have been recurrent fires.

B. Sagebrush-bunchgrass-giant ryegrass area of northeastern Nevada. These differ from the others in occurring in high intermountain valleys and on foothills and in having a prominent admixture of giant ryegrass.

C. Sagebrush-bunchgrass ranges of the Snake River Plains and adjacent foothills in Idaho. These areas possibly naturally have a larger proportion of sagebrush than the foothills of Utah, but the grasses have decreased and sagebrush increased, owing to over-use.

A. Sagebrush-bunchgrass ranges of Utah

The studies on the sagebrush-wheatgrass spring-fall ranges of Utah to date fall under three headings:

1. Reconstruction of original vegetation.
2. Natural revegetation studies.
3. Influence of spring-fall range on type of sheep production.

(1) Original Vegetation

The report of last year's Investigative Committee meetings gave a summary of studies on protected areas which indicated the original condition of native vegetation. About a dozen new areas have been added and these corroborate the previous data that wheatgrass was originally much more abundant, that sagebrush has greatly increased since grazing began, and that the adventive downy brome or cheatgrass (Bromus tectorum) does not even now occur in an important way in areas that are well protected, but it is so aggressive as to spread everywhere on heavily used spring-fall ranges of northern and central Utah. Two reports, one technical and one non-technical, have been prepared for publication on this study. The technical report will be published in Ecology and the popular treatise will be offered to the National Woolgrower.

(2) Revegetation Studies

The sagebrush-bunchgrass ranges in Utah have been so completely rundown, with few exceptions, that methods of revegetating becomes the most important phase of this project. Eight enclosures were set up in Utah during 1931 and the vegetation mapped down to areas of about 15 feet in diameter for use as check areas in determining possibilities in rehabilitation of depleted range. Three are 10-acre enclosures, set up with the

cooperation of the Fishlake, Manti, and Uinta National Forests on the spring ranges on the lower edges of these forests. Two 5-acre enclosures, two 2-acre enclosures and one 1-acre enclosure were set up on the spring ranges of the Uintah-Ouray Indian reservation with the cooperation of H. M. Tidwell, Superintendent of the Agency. There are also two enclosures on the purely spring-fall ranges of the lower fringes of the Boise Forest in Idaho, and two others just on the margin where spring-fall ranges merge into summer ranges.

(3) Survey of Two Sheep Communities with Different Type of Operation

A survey of two sheep communities in Utah begun in October, 1930 and reported on in a preliminary way a year ago, has been continued by visiting the ranges used and by contacting the outfits during the spring, summer and winter since the previous meeting. The striking differences in operation methods which result in a specialization in lambs by the Heber outfits and in wool by the Fountain Green outfits appear to be influenced in a fundamental manner by the differences in available spring range.

The Heber outfits, 20 in number and running 92,280 sheep, owned and leased 241,058 acres of spring range as compared to only 116,925 acres owned and leased by the Fountain Green outfits which had 93,750 sheep. The former have 2.06 times as much land, and the land is also enough more productive to make the available spring forage approximately three times as plentiful for the 92,280 Heber sheep as for the 93,750 Fountain Green sheep. The summer ranges also carry more succulent forage. The more favorable spring range, supplemented by a somewhat better summer range, has been found greatly to favor early, heavy range-fat lambs for early

fall "killer" market. Other differences in operation are that: the Heber outfits ran crossbred herds and fed as a 5-year average, four times as much corn to ewes on winter range and obtained a 94.0 per cent lamb crop, and a lamb weight of 74.4 pounds by September 19, as compared to 84.6 per cent lamb crop and 68.4 pound lambs by October 2 from fine wooled ewes obtained by Fountain Green operators. Costs of the extra land and extra feeding offsets more or less of the added production by Heber operators.

A paper entitled "Influence of Spring Range Lands on Type of Sheep Enterprise" has been prepared and will probably be offered to the National Woolgrower.

B. Northeastern Nevada

An examination in northeastern Nevada of the railroad right-of-way of the Southern Pacific Railroad which has been enclosed for about 30 years shows about 25 to 50 per cent more vegetation and some difference in species percentages on the right-of-way as compared to outside public domain ranges or to open private ranges.

Serious mineral deficiencies, particularly of phosphorus, are known to have occurred in South Africa and New Zealand. Reproduction has been greatly decreased and growth of animals retarded to the extent of destroying profitable grazing. In extreme cases pastures have been broken down and animals lose flesh almost to starvation condition. Animals have shown a similar condition but it is not as yet studied so fully in parts of Montana, New Mexico and California. In parts of northeastern Nevada the range cattle of 1931 showed a condition indicating mineral

deficiency and a survey was made to find if possible whether it seemed to be a phosphorus deficiency. The symptoms, appeared from observation to be positive. It is deemed desirable to follow this problem through 1932 and in subsequent seasons to determine if there is a mineral deficiency and the extent to which it is attributable to range depletion and if it can be corrected by range management. The agricultural extension agent at Elko and Supervisor McQueen are planning to cooperate with the Intermountain station in further observations.

8. Snake River Plains, Idaho (U.S. Sheep Experiment Station)

The studies in this division of the project are at present limited chiefly to the cooperative work by the Forest Service and the Bureau of Animal Industry on the Upper Snake River Plains at the U. S. Sheep Experiment Station range near Dubois, Idaho.

This study reveals further rather significant information regarding the influence which climate may exert upon range vegetation and sheep production. Phenological data show that height growth may vary 44 per cent from year to year. Quadrat studies indicate that there is a comparable variation in the density of the palatable vegetation. The carrying capacity conforms roughly to the fluctuations observed in the plant measurements - the feed produced in a special 80-acre pasture, for example, having varied from a maximum of 7500 sheep-days in the best year (1925) to a low figure of 3500 sheep-days in 1928.

In addition to a fluctuating height growth, density and volume of feed it has been observed that climate also materially affects the time when growth of forage starts each year and the length of the growing season.

The start of plant growth has varied from March 20 to April 25, a range of over 30 days. The time at which curing of the forage began was observed as early as June 10, in one year, and as late as July 25 in another, a range of over forty days. When correlated with weather records it appears that the start of growth largely is dependent upon the temperature whereas sequential growth is influenced almost entirely by precipitation.

Such vicissitudes in range conditions at a time of year when the operator is anxious to move his stock to the range to reduce feeding expenses and also requiring ample feed for lambing purposes, greatly complicates range management. It will be no simple task to develop systems of management that will afford the desired early use of the range and also prevent declining forage yields.

An analysis of a 24-year record of precipitation to determine the recurrence of drought, indicates that since 1917 only one year (1925) had precipitation above normal, the other years were considerably deficient in moisture. From 1906 to 1917, however, the reverse was true; one year was deficient in moisture but the other years were considerably above normal. Thus the first half of the period was one of range conditions above the average and the second was one of decline. The history of dry farming in that region bears out the precipitation record as crop failures have been prevalent the last half of the period and good harvests were more prevalent in the period of wetter years.

The cyclic occurrence of good and poor yields of years was further studied through an analysis of the 62-year record of precipitation at

Boise, Idaho. When summer precipitation is plotted as accumulated sums of departures from normal, there appear to be three complete cycles in the 62-year period, the longest dry phase of a cycle having been from 1896 to 1910, and the most recent from 1918 to 1931. The curve derived from departures of annual precipitation reveal similar trends. A wet period ended in 1875, dry periods occurred from 1876 to 1883, from 1886 to 1895, 1901 to 1910, and from 1918 to 1931, all inclusive, with intervening periods of precipitation above the average. Range management plans will have to be developed to meet these cyclic occurrences of wet and dry periods which so materially affect forage production.

Plans for Fiscal Year 1933

It is planned to do as much as time, funds and opportunity permit on the following ten phases of the problem, exclusive of the older work at the U. S. Sheep Experiment Station:

1. Community Surveys of Livestock Enterprises

Two communities, Heber and Fountain Green, have been surveyed and the data on another community partly taken. These surveys of community sheep enterprises furnish basic information on which to plan range management and are to be continued; one or more cattle communities are also to be surveyed to determine the relation of the use of the range to the particular type of operation practiced by a given community.

2. Reconstruction of Original Vegetation

Valuable data regarding the original plant cover of sagebrush-wheatgrass areas in Utah have been previously obtained. This accumulation of data is to be added to whenever and wherever areas are found which have

been protected in such a way and for a long enough period to make them valuable for this purpose. A picture of the original vegetation is essential for setting up the limits and direction of possible and probable range improvement under better range management.

3. Revegetation Studies

Suitable plots (quadrat, major plots, or line plots) for detailed study will be established both inside and outside the 12 enclosures so far established. A careful estimate of forage production will also be made in the various enclosures. A few more will be established.

4. Controlled (Pasture) Grazing

If a satisfactory cooperator can be found who has an area of spring range land and either cattle or sheep, a program in keeping with the set-up found will be initiated. Perhaps the most that can be done during 1932 is to search for a satisfactory cooperator.

5. Selection of an Experimental Range.

During 1932, a systematic canvass will be made of spring-fall ranges for an area of public land suitable for small experimental range in the south half of the region. So much of the area of these ranges, however, has passed into private ownership that it may be necessary to look for a permanent cooperator with land rather than depend on public land. It is highly desirable to find a set-up that will care for both cattle and sheep.

6. Utilization and Palatability

It is planned to study the influence of stage of plant development and abundance of forage on the relative palatability of species and

of combinations of species for cattle and sheep. It is desirable to study the degree of utilization in relation to feed scarcity and determine whether occasional full utilization if not repeated soon is harmful.

7. Sheep Herd Grazing Studies

The effect on forage productivity and utilization of different herding and lambing practices will be studied. Observations will be made as to whether certain sites are best used early or late and as to what is the influence on forage utilization of available water.

8. Climate and Plant Growth

As much data as conditions, funds and apparatus warrant will be gathered on the nature and distribution of storms on plant growth and on the period of species development (phenology). It is also desirable to learn how much influence drought, high wind, or unusual temperatures have on forage production and quality.

9. Special Mineral Deficiency Study

Along with other work in the neighborhood, a mineral deficiency problem in northeastern Nevada will be followed through 1932, and subsequent seasons if necessary, to make sure if it is a mineral deficiency, and whether range management will contribute materially to its solution.

10. Exploratory Ecological Studies

As a by-product of studies previously listed, a start will be made to accumulate data on the larger problem of influence of precipitation, temperature, soil, drainage, alkali, grazing, burning, rodents, etc., on the species distribution and species composition, and on reproduction, productivity, root development, plant succession, etc., of native plants.

Plans for the U. S. S. E. S. subproject

Plans for 1932 contemplate focusing more attention on methods of range rehabilitation. Several systems of grazing have been under study since 1923 which is deemed a sufficient period. Management to secure range improvement with use is badly needed for the bulk of this range type. It is planned that future studies will include a critical analysis of the deferred and rotation system of grazing, for which four additional paddocks were constructed during the last season. When available Paddocks 3, 8 and 9 will be used for additional systems of range improvement. These methods will be devised before the 1932 grazing season.

More detailed information is needed concerning climate and plant growth. To investigate these phases, a physical factor station should be established at the Sheep Station this year.

There is considerable pressure for a study of burning sagebrush as a means of range improvement. If circumstances justify one paddock may be set aside for this purpose.

Desert-Shrub (Semidesert Winter Ranges)

Since the project on management of grazing on the desert-shrub winter ranges is new, it has been necessary to explore the areas involved in a general way during the spring, summer, autumn and winter seasons. Accordingly, exploratory trips have been made over a considerable portion of the desert range area. Observations were made and data secured on the following points:

1. Major subdivisions and general nature of the winter ranges.
2. Nature and location of desert watering places.
3. Condition and distribution of desert-shrub vegetation.
4. Location of prospective sites for an experimental range.
5. Beginnings of data accumulation.

1. Major Subdivisions and General Nature of the Desert-Shrub Winter Ranges

The desert-shrub winter ranges of the Intermountain region are almost entirely public domain, except along land-grant railroads in Nevada and in southwestern Wyoming. The major subdivisions of these ranges, so far recognized, fall into five major subdivisions as follows:

1. Owyhee Desert of southwestern Idaho.
2. Southwestern Wyoming.
3. "East Desert" of Utah.
4. "West Desert" of Utah and eastern fringe of Nevada.
5. South central Nevada. (North central Nevada may be included in this subdivision or a new subdivision set-up.)

The first two of these areas, southwestern Idaho and southwestern Wyoming, have not as yet been explored. The other three have been examined in a general way and the "West Desert" somewhat more carefully.

The "East Desert" of Utah is a box canyon country with frequent deep arroyos leading into the box canyons. The geological formations are soft, easily eroded, and often contain soil alkali. The natural erosion is normally rapid but has been greatly accelerated since the period of settlement. The soils are predominantly clay and hard when dry, making

to all intents and purposes a run-off pavement but in other places Jurassic sands predominate. Access by stock to many areas is slow and difficult due to arroyos, and the feed is scarce due to naturally poor conditions and to heavy use. In western Utah and eastern Nevada, the ranges are smoother in topography, being largely old Lake Bonneville bottoms with low mountains or high hills between. Where the hills are high they have open passes through them. Central Nevada is almost a replica of western Utah except that there is proportionately more bottom (playa) and less hill land.

2. Watering Places

The watering places are far between, 5 to 25 miles, with about 12 to 15 miles very common. About half of these are in the flat bottoms (playas) and their waters are somewhat alkaline. A few are warm or hot springs. Another half of them are apparently fresh mountain water. All except two or three, are small and many of them went dry during the unprecedented drought of 1931. Curiously enough, two large springs, and several of the smallest showed no visible effect of the drought.

There are a few water developments, some being dams built across natural drainages to store run-off and some are wells. On account of these ranges being without control, however, stockmen have not cared to invest in water developments which transient operators might not only use before the builder was ready, but also make use of it to graze in early fall or even in summer and thereby strip before winter, a range hitherto used for winter grazing and on which a regular outfit was depending. Not only are stockmen reluctant to develop water under such conditions but it

is doubtful that they (or anyone else) should do this until there is such a control of these winter ranges as will symchronize their use with summer ranges which in the Intermountain region are practically all on national forests.

3. Native Vegetation: Nature and Condition

Winter range vegetation is largely small browse, some grasses and a few weeds. The principal forage plants are as follows:

Shadscale (Atriplex confertifolia)

White sage (Eurotia lanata)

Little rabbitbrush (Chrysothamnus spp.)

Bud sage (Artemisia canescens)

Black sage (Artemisia nova)

Brigham tea (Ephedra spp.)

Sandgrass or ricegrass (Oryzopsis spp.)

Galleta grass (Hilaria jamesii)

Three-awn grass (Aristida spp.)

Mustards (Sophia)

False mallow (Spaeralcea spp.)

In addition a saltweed (Atriplex nuttallii) locally known as "Castle Valley clover" is a very common on the eastern Utah desert.

In May and early June, as an incidental feature of trips for other purposes, into western Utah, plant collections were made of 25 shrubs, 26 grasses and 67 weeds.

Throughout the areas examined the more palatable species, especially black sage and white sage, near watering places had been greatly weakened, apparently by repeated over-utilization. In many places dead and near-dead stumps of these plants were found in considerable areas. Many dead shadscale plants were also found though usually in a more scattered distribution. Many dead grass stumps were found in some areas. In the Utah-Nevada winter range, where this depletion near watering places was most studied, little rabbitbrush seemed to be invading the areas of weakened white sage and shadscale. Such casual observations need to be verified by more careful subsequent study. Some stockmen claim a "good year" is all that is necessary "to bring back" the range. This is not fully substantiated.

Eight to ten miles from watering places little dying vegetation was found and there was less evidence of decreased vigor, except in the northern end of the area, in the general vicinity of the Great Salt Lake desert, where there were widespread signs of loss of desirable species, and of weakened vigor in persistent species, possibly owing to drought.

4. Prospective Sites for Experimental Winter Range

Six prospective sites for an experimental range on the winter range were tentatively chosen in Tooele, Millard, and Beaver counties in Utah. The possible sites, after further study, were reduced to three. Maps of vegetation, a list of types and a report were prepared for each area. The report is now being studied by the Washington office. The following vegetational types were represented in appreciable areas:

White sage

Shadscale

Shadscale-white sage

Shadscale-rice grass-white sage

Shadscale-white sage-galleta grass-little rabbitbrush

Shadscale-galleta grass-white sage

Tetradymia-rabbitbrush-galleta grass

Pinyon-juniper

Shadscale-white sage-rice grass-grama grass
(with and without Ephedra)

Ricegrass-grama grass-galleta grass

Black sage-shadscale-rice grass

Black sage

5. Beginnings of Data Accumulation

Studies have been begun on a few preliminary problems and some data secured.

(a) In much of the western Utah-eastern Nevada area vegetation is in belts and differs widely in density and forage value. Evidence seems to suggest soil differences as being responsible for such vegetation. Two transects have been laid out so as to run across the belts of vegetation for about 1½ miles in one, 4½ miles in the other. Stations were made 100 feet apart in one and 200 feet in the other which was longer. Vegetation was mapped and surface soil examined. Alkali was found to be widely different in the surface samples. About thirty critical soil samples were drawn from each transect to a depth of six feet.

These are being studied in the laboratory. Density of the vegetation varied from .0170 to .1500 on one of the transects.

(b) There is only one weather record being kept in the whole western Utah-eastern Nevada area. Two emergency stations were set up in May, 1931. To date they show very high temperatures and practically no rain in summer followed by extreme winter cold and heavy snow in December and January. Stockmen say the summer drought and the winter snow and cold of 1931-32 were the worst ever experienced or at least for many years. No correlation whatever was found with regard to the occurrence of summer storms at the two new stations 33 miles apart.

(c) Plant growth measurements were made in ten localities in western Utah. Three locations were found where on a few acres the growth was thought to be almost as good as normal due to flood waters having ponded after the one or two rapid rains. Seven plots were marked for study in subsequent years. Measured plants were selected at random by stretching a line from a given point and measuring every plant touched by the string until 50 plants were obtained. The current year's twig growth for 50 plants to a site in western Millard county were as follows:

Shadscale	White Sage
* 10.3 cm.	4.9 cm.
6.1 "	2.8 "
6.5 "	* 5.6 "
3.5 "	

In seven other localities widely scattered over western Utah 20 shadscale plants in each designated locality taken at random gave the following measurements of twig growth:

*	Skull Valley	11.0 cm.
	Callao	3.1 "
	Trout Creek	3.0 "
	East of Trout Creek	6.2 "
*	Sand Pass	10.6 "
	Sand Pass	4.9 "
	Joy	3.5 "

* Flooded but not fully normal in amount of growth.

About 20 miles north of Tonopah, Nevada, is an area of a few miles that received good rains in 1931. Growth of twigs there were as follows:

Shadscale	11.5 cm.
White sage	17.2 "
White sage	12.8 "

Judged by these few measurements and by observations there seems to have been a growth of about 43 per cent of normal on the western Utah-eastern Nevada and on the central Nevada winter range areas. Once in regular operation such measurements taken widely over the desert will serve as a measure of forage production and would be valuable information in the fall to stockmen.

(d) A visit to 17 winter herds in western Utah in Jaunary, 1932, revealed scarce feed, poor condition of sheep, and considerable winter feeding. Winter losses were beginning to be heavy. The herders estimated the causes of these losses as due to -

Starvation and cold	90%
Coyotes	4%
Lip and leg disease	5%
Other causes	1%

Under conditions of great scarcity of forage, observations in January, 1932, showed black sage, rice grass, and white sage at that time to be taken fully (100 per cent), rabbitbrush and galleta grass 30 per cent, shadscale 15 per cent, and grama grass 5 per cent.

(e) Plant-sap Studies. Some years ago, as part of a larger study of plant-sap properties Dr. J. Arthur Harris, head of the Botany Department of the University of Minnesota, made determinations of sap properties of range plants in the vicinity of the Great Basin Branch Station, extending from the mountain into the desert. This station cooperated in the original field study on the mountains. Dr. Harris died before he had completed field work or analyzed his data. Arrangements have been made with Doctors Gortner, Rosendahl and Burr of the University of Minnesota, who have the records in charge, to separate out the data in which the Intermountain station has an interest. Some 10,000 figures of these data have now been received. These data are of special interest to the station, since they represent areas under study on desert, intermediate and summer range. Available range data will be added and the records placed on punch cards for machine analysis.

Plans for Fiscal Year 1933

It is planned that during 1932 as much progress as time, funds and opportunity permit, be made on the following eight phases of this project:

1. Final Selection of Experimental Range

Until final designation of the experimental range is made the project plans cannot go forward properly as they depend to an appreciable extent on the particular range chosen.

2. Completion of Project Working Plans

As soon as the experimental range is finally selected, the project working plans are to be completed. A number of these features, not dependent on the site of the experimental range, have been planned for as briefly outlined in the subsequent paragraphs.

3. Palatability and Utilization Studies

A study will be made of palatability to both cattle and sheep of various forage species and of the degree of utilization at different seasons of the year and with various degrees of forage abundance.

4. Natural Revegetation Studies (Enclosures)

It is planned to erect as rapidly as funds permit a series of small enclosures (1 to 5 acres in size) on representative cattle and sheep winter ranges. The vegetation will be mapped and density and species studies made. Suitable plots for detailed study (quadrat, major plots, or line plots) will be set up both inside and outside. These plots will be made on fully protected, on partly grazed, and on open range areas.

5. Sheep Herd Grazing Studies

Observations are to be made of the way in which sheep herding practices affect forage utilization, and the period in the grazing season when it is best to utilize the various plant combinations, and when and how best to graze sites of different physiographical aspect. It is planned to observe, if possible, the effects on the open range of intense utilization at one grazing as compared with repeated light use. Perhaps this can be done only in fenced pasture grazing.

6. Climate and Plant Growth

Since there are practically no climatic data regarding desert-shrub areas, as much information as possible will be accumulated on temperature, rainfall, and winds. Growth measurements will be taken, particularly with reference to major soil types and drought periods. It is desirable as well to learn the seasonal periods at which plant development reaches certain stages (phenology).

7. Exploratory Ecological Studies

Preliminary observations are to be made, and easily obtainable data accumulated, on the influences of the various ecological agencies such as precipitation, temperature, soil, drainage, alkali salts, grazing, rodents, etc., on the development, species composition, seed production, root development, plant succession, etc. of native vegetation.

8. Methods of Studying Shrubby Vegetation

Since quadrats are not adequate for shrubby vegetation, it is planned to investigate in a preliminary way the sort and number of plots which, with the least expense in time and funds, will give representative data for a desert-shrub area. It is not clear how truly to cross-section such a shrub type, nor is it known how many plants a plot unit should contain nor how many plot replications are required to reduce the error due to natural variability to reasonable limits. Some consideration is to be given to the method of statistics applicable to such data.

ARTIFICIAL RESEEDING

Artificial reseeding is confined to the various vegetative zones on the Wasatch Plateau. Table 1 shows the new artificial reseeding test plots established in 1931. Of these the plantings of yellow sweet clover, white sweet clover, crested wheatgrass (A. cristatum), brome (B. inermis), and Medicago lupulina were made in cooperation with the Bureau of Plant Industry. Five species were sown on the snow in March. Replication sowings of several species were made in accordance with plans to repeat seasonal sowings for several years. Nursery sowings were made of several species with seed collected from plants grown from previous sowings. A portion of the plantation was grazed in 1931 to ascertain the effect of use on established plants.

The improvement in forage production by several species as observed in 1931 on areas sown in 1929 in rabbit-proof enclosures is shown in Table 2.

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The existing circumstances are such as to demand that no new tests be started in 1932 with any species and that the work of the season be limited to the observations necessary for the tests already started and to compilation and analysis of available data. This project has now grown to where it and other going projects will require all the field time available. Compilation is running behind. On top of this reduced funds for the fiscal year make matters still more difficult. It will be wisdom to forego any more new tests this year.

Table 1.

1931 ARTIFICIAL RESEEDING TESTS

Species	Source of Seed	Plantation	Nursery	Total
	Tame Species			
Grasses				
Agropyron cristatum	Dickinson, N. D.	3	1	4
" "	Oak Zone - Manti N. F.	0	4	4
Bromus inermis	Lawrence, Kansas	3	1	4
" "	Oak Zone, Manti N.F.	0	3	3
Others				
Atriplex halimus	Morocco	0	2	2
Erodium cicutarium	Medford, Oregon	0	1	1
Medicago lupulina	Alabama	0	3	3
White sweet clover	Oak Zone - Manti N.F.	0	2	2
" " "	Great Basin Branch Nursery	0	1	1
Yellow sweet clover	Oak Zone - Manti N. F.	0	5	5
" " "	Denver, Colorado	3	0	3
	Total Tests of Tame Species	9	23	32
	Native Species			
Grasses				
Agropyron caninum	Cache N. F., Utah	0	1	1
" spicatum	Oak Zone, Manti N. F.	0	1	1
" tenerum	" " " " "	0	2	2
" violaceum	Spruce-Fir Zone, Manti N.F.	1	6	7
" "	Great Basin Branch Nursery	0	1	1
Bromus polyanthus	" " " "	2	2	4
" "	Oak Zone - Manti N. F.	0	2	2
" "	Seeley Cr. - Manti N.F.	0	2	2
" porteri	Oak Zone - Manti N. F.	0	2	2
" "	Spruce-Fir Zone, Manti N.F.	0	2	2
" pumpellianus	Leadville, Colorado	0	1	1
" "	Oak Zone - Manti N.F.	0	1	1
" subvelutinus	" " " " "	0	1	1
Poa fendleriana	" " " " "	0	2	2
" pratensis	" " " " "	0	2	2
	Total Tests of Native Species	3	28	31
	Total Tests of All Species	12	51	63

Table 2.

Per Cent Increase in Carrying Capacity as Result of the Artificial Reseeding

Area	Method of Soil Treatment	Species				
		Common brome	Crested wheatgrass	Many-flowered brome	Violet wheatgrass	Yellow sweet clover
Elevation 8,000 feet		%	%	%	%	%
Heavy sagebrush and from small clumps to thickets of oak.	Seed sown in plowed furrows and then covered with brush harrow.	34	36	49	42	33
Rather dry site and soil fairly deep gravelly loam.	Seed sown broadcast and then trampled in with sheep.	0	23	0	-	0
Elevation 8,200 feet						
Open to fairly heavy stands of sagebrush and heavy clumps of oak.	Seed sown in plowed furrows and then ~~and then~~ covered with brush harrow.	51	44	46	-	38
Favorable site and soil fairly deep clay loam.	Seed sown broadcast. No treatment.	14	21	17	-	-

EROSION AND STREAMFLOW

Bunchgrass-Granitic Soils

Indications that the run-off from the Boise River watershed was reaching a peak early in the irrigation season caused much alarm among the water users in Boise Valley and led to the initiation of studies in 1929, of the factors influencing erosion and streamflow on this watershed. These studies involve (1) a combination grazing-erosion survey to determine the extent of erosion and what are the influencing factors, (2) a preliminary investigation of climate and melting snow, and (3) an inspection of soil profiles and vegetative associations in relation to erosion. These studies were continued through 1931 as a basis following which more detailed investigations will be initiated.

It has been computed that every acre of the 1,700,000 acres on the Boise River watershed represents a capitalized value in Boise Valley, exclusive of buildings, farm equipment, livestock and planted crops, of approximately $32.00. Another computation, based on the yield and value of water diverted to the valley lands indicates that each acre of the watershed annually yields a supply of water worth approximately two dollars.

The range erosion survey which covered approximately 300,000 acres, revealed conditions of accelerated erosion on much of the watershed. No erosion was observed on 38 per cent of the area examined; 2 per cent showed serious erosion; 8 per cent was fairly heavily eroding; and 52 per cent was eroding only slightly. Correlation of degree of erosion

with plant types, density of vegetation, slope, soil, aspect, rodent infestation, and degree of accessibility or use by livestock show the following:

1. There is a correlation between degree of erosion and cover type although it is not as high as might have been expected. The plant types fall in the following ascending order of susceptibility to erosion: Barren type, which showed no accelerated erosion, waste range in dense timber, timber, sagebrush, grass and weed, the last shown, the highest susceptibility. It is of interest to note that the types rank in the same order with respect to susceptibility to erosion as to grazing value.

2. As would be expected there was a marked tendency for erosion to be in inverse relation to plant density and more especially to decline in density from previous condition. However, in some of the types, especially weed and sagebrush, degree of erosion did not correlate well with density.

3. There was only fair correlation between percent of slope and degree of erosion. From 0 to 30 per cent slope there was a fairly constant increase in erosion with increase in slope. From 30 to 70 per cent, increase in slope did not consistently increase erosion. This appears to be due to reduction in accessibility or convenience with which range may be grazed, with increase in slope beyond 30 degrees.

4. Degree of erosion was more or less inversely proportional to the texture of the soil. In other words, the coarser the soil the worse the erosion. Also, the less the humus content or the more shallow the soil, the greater the erosion.

5. Aspect influences the surface climate, soil, vegetation, rodent population, and directly or indirectly, the degree of erosion. Erosion ranged as follows through the various aspects: Heaviest on south slopes followed by southeast, east, southwest, west, northwest, northeast, and was least on the north slopes.

6. Degree of erosion varied more or less directly with degree of rodent infestation, the pocket gopher being the most common rodent.

7. The highest correlation obtained was between accessibility to livestock and erosion. Accessibility is largely a measure of degree of ease of occupancy of the areas. In other words, erosion increased with increase in occupancy by livestock, regardless of type, density of vegetation and other factors.

A manuscript for publication is in course of completion covering the results of this study.

Regular observations were made in 1930 and 1931 to compare the relative degree of erosion during the vernal melting and the summer rainfall periods. Results at the Great Basin Branch previously had indicated that summer precipitation caused by far the larger portion of the erosion. The melting period of both years were preceded by relatively light snowfall and the temperatures were moderate most of the time. Little erosion resulted from melted snow run-off. A few local torrential rains in 1930 caused heavy sheet and gully erosion. What erosion will follow a year of heavy winter precipitation and quick spring melting remains to be seen.

Investigations of soil profiles suggests that over much of the present or potential bunchgrass type the top layer of dark soil is now missing. On selected sites which, through protection, now support luxuriant

stands of vegetation, analysis shows the soil to consist of about 46 per cent gravel (particles 2 mm. in diameter or larger), 34 per cent sand (particles 0.2 to 2 mm. in diameter), 15 per cent silt (particles 0.02 to 0.2 mm. in diameter) and only 5 per cent clay (particles less than 0.02 mm. in diameter), with an organic content of 10 per cent, 0.45 per cent nitrogen, and a water-holding capacity of 81 per cent. The top soil of the great bulk of the bunchgrass type consists of about 55 per cent small gravel, 30 per cent sand, 10 per cent silt and 5 per cent clay with 2 per cent organic matter and 0.15 per cent nitrogen and a water-holding capacity of 44 per cent. The present top layer of soil over much of the watershed compares almost exactly with the 10-20 inch horizon underlying the surface of the best sites. The soils in general are so coarse, of such low water-holding capacity, and so lacking in "binding" power, due to the nearly entire absence of clay, that they are easily moved by running water.

Studies of the vegetation found on the watershed reveal a striking analogy to the soil profile studies. A distinct association of species characterized by Agropyron spicatum, Balsamorhiza sagittata, Lupinus comatus and other hardy perennials, was found on all of the best sites. The scattered occurrence of these species today suggests that this luxuriant association formerly extended over a much greater portion of the watershed. The importance of the climax formation in preventing erosion appears to coincide with the higher water-holding capacity of soils on which it occurs, as compared to the less retentive characteristics of soils over much of the watershed where erosion is now prevalent

and where subclimax associations of plants representing low densities and low forage value, are common.

An analysis of the factors affecting the yield of water from watersheds has suggested a formula which indicates that the water available for diversion to irrigation ditches equals the total meteoric supply falling on the watershed, less amounts which are lost through direct evaporation, transpiration, interception-evaporation, abysmal seepage, and water of combination. On the basis of present meteorological data it appears that the yield of water from the watershed may be as high as 60 per cent, with the balance, or 40 per cent, being lost through the factors listed above. This is considered a very high yield. However, yield in volume of water alone is not the whole story. To be most useful run-off must be sustained and steady, as well as free from silt and other debris.

The yield of water is delivered chiefly by two methods: (1) underground or deep seepage, and (2) surface or surficial run-off. Excessive surficial run-off is usually accompanied by increased silting. The problem involved on the Boise watershed, therefore, lies in determining what vegetative cover and other surface conditions will reduce surface run-off to a minimum and, at the same time, will maintain or increase deep seepage.

Plans for Fiscal Year 1933

1. The measurement of the influence of different kinds and degree of herbaceous cover, slopes, depth of soil, character of soil and extent of trampling upon degree of surficial run-off and erosion from rainfall. This involves the perfection of equipment to produce the equivalent of rainfall. Such equipment to produce rainfall conditions as desired, will obviate the long delay and expense of waiting for natural rains on permanent installations.

2. The measurement of surface run-off from melting of snow in the spring (and incidentally from such summer rainfall as occurs) under several more important conditions of precipitation, slope, soil and cover. This involves the installation of several surficial run-off plots equipped to measure amount and rate of precipitation, run-off and erosion.

3. The measurement of interception of precipitation by the surface soil layer, evaporation loss of bare soil, and transpiration loss from plant covered surfaces. This involves the installation of interception pans, lysimeters and lysiphytometers under at least two site conditions.

4. A recheck of 1929 erosion profile surveys, not checked in 1931.

Colorado River Watershed Erosion Survey

An extensive field examination of the Upper Basin of the Colorado river in Wyoming, Utah and Colorado was made in 1931 to gather more definite information as to existing erosion conditions. Region 2 of the Forest Service detailed one man for service on this project in Colorado. Some 40 random sample areas scattered widely over the watershed of about 98,000 square miles were examined in the course of the work.

Three degrees of erosion were recognized as follows:

Serious erosion; where there is fairly general sheet erosion, shoestring gullies on slopes are frequent and canyons and valley bottoms nearly always are newly and deeply trenched with recent washes.

Moderate erosion; where there is more or less sheet erosion, occasional hillside shoestring gullies or scattered small areas sheet and gully eroded, and occasional or minor trenching in valley bottoms.

Light erosion; where there are few or no gullies, practically no sheet erosion and little or no unusual channeling in valley bottoms.

Approximately 50 per cent of the area of the watershed falls into the serious erosion class, 27 per cent in the moderate class and only 23 per cent into the lightly eroding class.

The most actively eroding areas are generally at low or medium elevations, on foothill, plateau, and bench lands where the soils are of sedimentary origin and the vegetation naturally sparse. Although existing conditions of climate, soil, topography, and the attendant sparse cover of native vegetation are conducive to a high natural rate of erosion on much of the lowland area, there has been a material acceleration in the rate of erosion during the last several decades. Accelerated erosion at the higher elevations exists on areas formerly little eroded where the formerly fairly dense vegetation has been depleted by overgrazing and fire. Such areas are extensive in the aggregate. The period of increasing erosional activity is coincident with the period of settlement by man and of increasing intensity of grazing use by domestic livestock. The deleterious effects of the excessive erosion and run-off which are excessive silting of streams, depletion of surface soils on range lands, arroyo-cutting, cutting away of farm lands in mountain valleys, deposit of debris on cultivated

lands, and floods, are of immediate and extreme importance to every phase of human endeavor in the Upper Basin. These include agriculture, resident irrigation, power, and livestock interests, and railroad, highway, and community developments and in addition the irrigation and power developments which are situated in the Lower Basin states of Nevada, Arizona and California.

Further research is necessary to determine for each of the varied physiographic conditions of the region, the extent to which depletion of plant cover and other factors incidental to its use and possible climatic change, are responsible for the accelerated erosion; the efficiency and function of various kinds of native vegetation in controlling run-off and erosion; the methods for restoring depleted vegetative cover; and the conditions under which the range plant crop may be utilized.

A more detailed report of the 1931 field survey is in course of preparation which will give findings on all the areas examined, including specific evidence of accelerated erosion. Further field examination to include the drainages of the Paria, Escalante, and Fremont rivers is contemplated prior to June 30, 1932. Completion of this field work and the report will complete the survey.

Utah Flood and Erosion Survey

A cooperative project participated in by this station, the Utah State Land Board and Utah State Agricultural Experiment Station, was undertaken during the present fiscal year. Approximately 30 flood areas in the state were examined during the field season and existing conditions of cover, slope, soil and other factors on the watersheds were recorded in detail.

Based largely on different interpretations of geological evidence on the flood areas, considerable difference of professional opinion has developed as to whether or not these floods are the usual or an accelerated phase of geological processes occurring throughout the region involved.

Preliminary conclusions pending further analysis of the data collected generally bear out the 1930 studies in Davis county which assign sparseness or depletion of plant cover on critical areas near the heads of drainage as the chief contributory cause of the recent excessive erosion and floods. There is indicated a need for more localized experimental work to determine the relative influences of various types of plant cover, soils, geological formations, and climatic factors in producing the floods and accelerated erosion. The possibilities of both natural and artificial revegetation in watershed protection should be further investigated. The need is also shown for the development of a land management policy, which will afford regulated grazing use on private, state and open public domain watershed lands so situated as to exert material influence on the use and condition of arable lands and other values below them.

The previous presence during Pleistocene times of Lake Bonneville in the basin into which drain the canyons of northern Utah that flooded in

1930, afforded an opportunity seldom met with elsewhere for studying the accelerated erosion and floods of recent years in relation to normal geologic processes. The conditions found bear out the conclusion that vegetation plays a leading role in regulating run-off and preventing erosion by torrential summer rains. A manuscript presenting the results of this study has been prepared for publication.

A report covering the results of the more extensive survey of 1931 will be prepared before June 30, 1932. This will complete the flood survey.

Great Basin

Plans for Fiscal Year 1933

1. A preliminary study of the influence of herbaceous vegetation on surficial run-off and erosion was carried on on the Wasatch Plateau from 1915 until 1929. The results were published in Technical Bulletin 220. This study did not take into consideration dissipation of the moisture that entered the soil, evaporation from snow surface and some of the soil factors. It is planned to continue this project and to supplement it with measurement of water losses from bare soil and through transpiration, through the installation of at least two sets of interception pans, lysimeters and lysiphytometers with the typical heavy clay soils of the region. Small surficial run-off plots will be established to study surficial run-off and erosion from the different soil horizons that have been exposed by past recent erosion.

2. Planting of herbaceous, shrubby and tree species will be required to revegetate depleted watersheds. Cooperation will be sought from the Utah State Land Board and Salt Lake City to undertake some planting to check erosion tests on Davis County and Salt Lake City watersheds.

3. During the spring of 1932 a thorough investigation will be made of the suitability of conditions on the Salt Lake City municipal watersheds as a site for installations and other erosion-streamflow investigations for the quartzite-schist soils. Several streams are very accurately gauged for municipal water supply and afford an opportunity for studying the effect of different conditions on streamflow and erosion. Salt Lake City may decide to cooperate in this investigation.

4. A working plan for the final project will be completed during the year.

BIOLOGICAL INVESTIGATIONS

(In cooperation with the Biological Survey)

An associate biologist was assigned to the station by the Biological Survey from August 1, 1930 to November 30, 1931.

The major biological project consisted of a study of the relation of rodents, more especially pocket gophers, to erosion in the bunchgrass type on granitic soils. Five rodent-proof enclosures with appropriate protected and unprotected quadrats and major plots were established during the year. The biologist also carried forward investigations in the life history of the pocket gopher. The cooperation of the rodent control leader for the State of Idaho was obtained in reducing the number of rodents by poison baiting on approximately 20,000 acres of the Boise River watershed. Two small complete drainages within the control area were left intact for use as check plots against the treated area.

The station biologist also cooperated with the station and the region in planning projects for the study of management of deer on the Middle Fork of the Salmon River in Idaho and on the Kaibab National Forest in Arizona.

Four 40x40 foot enclosures, distributed in the vegetative zones on the Wasatch Plateau at the Great Basin Branch Station in 1931, were fenced rodent proof. These were established for the purpose of studying the influence of rodents on the native vegetation and on results of artificial reseeding. The station biologist cooperated in the establishment of these plots.

Four natural revegetation enclosures in the oak zone on the Wasatch Plateau were fenced deer-proof in 1931 in order to measure influence of deer grazing in the natural revegetation studies.

Plans for Fiscal Year 1933

Plans for biological investigations for the coming fiscal year are indefinite owing to the station biologist having resigned and no successor selected. The biological studies should be carried currently with the range studies, and it will be unfortunate if no one will be available to handle the biological phases. It has been recommended to the Biological Survey that the position be filled or an assistant assigned temporarily for part of the field season.

PROPOSED NEW PROJECTS

Several new projects have been proposed in reports of the past several years. These are as follows:

1. Artificial reseeding of range lands.....$25,000.00
2. The influence of the ponderosa pine type on granitic soils (including methods of cutting) on run-off and erosion..... 20,000.00
3. Forest fire study..... 7,500.00
4. Growth and yield of ponderosa pine..... 10,000.00
5. Range land economics..... 6,500.00
6. Forest entomology..... 5,000.00
7. Forest and range biology..... 10,000.00

The need for these items has been set forth in previous reports and will not be repeated here except to realign them in the order of priority from the standpoint of need, add an item for erosion and streamflow study in the Colorado River, and discuss further a few of these items. This list is as follows:

1. Artificial reseeding of range lands.....$25,000.00
2. Forest fire study..... 7,500.00
3. Erosion and streamflow Colorado River..... 25,000.00
4. Forest and range biology..... 10,000.00
5. Erosion and streamflow, ponderosa pine type..... 20,000.00
6. Growth and yield of ponderosa pine type..... 10,000.00
7. Range land economics..... 6,500.00
8. Forest entomology..... 5,000.00

It is difficult to arrange the first three as to priority because they are all urgent. Forest and range biology was being partially taken care of by the assignment of an associate forest biologist to the station. However, he has resigned, and the Biological Survey reports the place may not be filled immediately owing to necessary economies. This is going to disrupt important work which should be resumed as soon as possible. Some points in connection with the first three items are as follows:

Artificial reseeding of range lands.

The demand for more useful information on species and methods for range reseeding is continually increasing. This has been stimulated by the recently published artificial reseeding bulletin. Satisfactory species and methods for artificial reseeding would stimulate improvement of the forage and plant cover on 50 to 80 million acres of range land in the Intermountain region alone on much of which the more valuable forage species are so depleted that restoration by natural revegetation under any condition is almost out of the question. Successful artificial reseeding is needed as a means of meeting the erosion and run-off problem on these lands. Any known cultivated species are out of the question for use on the foothill or desert areas of the region because of rather unfavorable growing conditions. Native species have not been adapted to artificial seeding. The situation demands an early start to develop through trials, breeding, selection and importation, suitable species for the semidesert and foothill areas. If a half dozen good species could be developed in ten years of investigation under this project, they would return the cost many-fold. People of the West will lose faith in / the range research program of

the Forest Service if it does not include a strong attack of the artificial reseeding problem.

Forest fire study.

The fire season of 1931 in southern Idaho developed a problem which demands a strong research attack to meet. The area burned on the eight "fire forests" was 190,893 acres in 1931 as compared to an average annual burned area of 23,489 acres during the previous 10-year period and 49,244 acres in 1929, the worst year during the 10-year period. Cost of suppression jumped to $587,224 in 1931 as compared to an average of $26,434 for the 10-year period and $93,735 in 1929. It was the worst year ever experienced on the area in National Forest history. It was due to climatic conditions which developed an especially high degree of inflammability of forest fuels. Even the live plant growth attained a condition on some days that permitted it literally to explode when ignited. A fire which under normal conditions would require a given sized crew to control it in 1931 required 10 or more times as many men. As the full gravity of the situation was not realized sufficiently in advance to prepare the fire organization best to meet the emergency, many fires became so large extremely heavy expense was necessary to control them. Because such years as in 1931 occur only at intervals of many years, the fire organization can not ecnomically be kept up at all times to a force capable of meeting the occasional peak year so that some means must be provided for foreseeing the approach and preparing for the occasional more hazardous conditions. This is the job for research.

The project would provide for a study of combustibility of live vegetation, including reproduction and other forest growth as well as of duff and other forest litter and the climatic conditions giving rise to hazardous conditions, and develop a method of foreseeing the approach of these conditions. This would make it possible to plan sufficiently in advance, for the strengthening the normal fire organization in accordance with the needs. The studies must be made under local conditions for it is evident that results of similar studies in other regions do not apply specifically enough for the particular conditions in the Intermountain region.

Erosion and streamflow, Colorado River.

A preliminary survey indicates that of the land area in the upper Colorado river basin, 50 per cent is eroding seriously, 27 per cent moderately, and 23 per cent is eroding little or none. The annual silt load of the Colorado river is more than 250 million tons at the site of the Hoover dam. Previously well aggraded valleys throughout the area now have newly cut channels in some places as much as 100 feet in depth and several hundred feet in width. The best arable land in narrow mountain valleys is being eroded away and carried down the streams. Much of the lowland area has a geological formation, soil, climate and sparsity of vegetation that is conducive to a high rate of natural erosion. The uplands, however, naturally support a cover capable of holding erosion well in check. There is no doubt that excessive use of the plant cover by grazing, fire, drainage of beaver dams, cultivation, road building and other works of man have materially modified and thinned the plant cover and

modified the surface soil to a degree that erosion has been materially accelerated. That the rate of erosion has been materially accelerated since white man occupied the region, is evident. The extent to which this is due to man's disturbance of vegetation, and the extent to which plant cover can be restored and utilized in controlling erosion and regulating the streamflow is a problem needing study. Thus far most attention to silt control has been directed to dams and other works to store the silt. Practically no action has been directed to preventing erosion and keeping the silt out of the streams and in place on the land where it will produce a crop. The Colorado River and its drainage basin is of such great importance to the development and future of the entire Southwest that no opportunity should be overlooked to maintain every condition in the highest state of usefulness.

PROGRESS WITH PUBLICATIONS DURING THE YEAR

In Manuscript Form

For Department Publication:

E. W. Nelson: The influence of precipitation and grazing upon black grama grass range. (J.A.R. or Dept. Tech. Bul.). Being resubmitted to the editor in March 1932 and should be published before June 30, 1933.

F. G. Renner: Erosion on the Boise River watershed as affected by various biotic and physiographic factors (USDA Tech. Bul.). Being revised by author following board of review comments, should be published during F. Y. 1933.

R. W. Bailey, C. L. Forsling, and R. J. Becraft. Floods and Accelerated Erosion in Northern Utah. (USDA Circular) Submitted to editor, should be published within a year.

C. L. Forsling, G. W. Craddock, and W. A. Denecke. The influence of climate and methods of management on spring-fall range in relation to range sheep production in southeastern Idaho. (USDA Tech. Bul.) First draft of manuscript about completed. Should be ready for Board of Reviews by June 30.

C. K. Pearse. A preliminary ecological study of the vegetation on a portion of the Boise River watershed in relation to livestock grazing. (J.A.R.) Manuscript to be completed by June 1 and submitted to editor. Should be ready for J.A.R. by Jan. 1, 1933.

Ready for Publication

Article by

Kenneth Pearse. An Area list method of measuring plant populations. Will probably be accepted by Ecology or similar journal.

George Stewart. Some statistical methods for range studies. (For some technical journal.)

George Stewart. Relation of spring ranges to sheep production in Utah. (To be offered to Woolgrower.)

G. D. Pickford

G. D. Pickford. Present condition of spring ranges in Utah. (To be offered to Producer or Woolgrower.)

Some Prospective Manuscripts for F. Y. 1933

George Stewart, et al. Characteristics of some eroded and uneroded soils of the Intermountain region (J.A.R.).

M. H. Deming. Erosion situation in the upper Colorado River basin. (Dept. circular?)

C. A. Connaughton. Growth of ponderosa pine during twenty years following selective cutting. (J.A.R. or Jour. of Forestry).

C. A. Connaughton. Growth in a virgin stand of ponderosa pine in Idaho. (J.A.R. or Jour. of Forestry).

H. M. Shank. An analytical study of forest fires in the Intermountain region. (Tech. Bul.)

L. F. Watts and C. A. Connaughton. Influence of forest cover on accumulation and melting of winter snow. (Progress report.)

Projects ready for compilation, analysis and report.

C. L. Forsling and Geo. W. Craddock, Jr. - A study of the influence of different degrees, frequencies and seasons of grazing and harvesting on the yield of range forage. Technical report on result of eight years of study.

E. W. Nelson - The effect of year to year variations in climate on the growth and development of important range plants in three climatic zones on the Wasatch Plateau of Utah.

E. W. Nelson - Fifteen years of plant succession in the revegetation of depleted mountain grazing lands on the Wasatch Plateau of Utah.

C. L. Forsling and George Stewart - The sigdificance of cell sap characteristics in the study of range vegetation.

Accepted for Publication (Articles)

L. F. Watts - Green gold for yellow; American Forests & Forest Life.

G. D. Pickford. The effect of past grazing practice and fires on the vegetation and grazing capacity of spring-fall range in Utah. Ecology.

Published Since Last Report

Department publications:

C. L. Forsling - A study of the influence of herbaceous plant cover on surface run-off and soil erosion in relation to grazing on the Wasatch Plateau in Utah. U.S.D.A. Technical Bul. No. 220.

C. L. Forsling and W. A. Dayton. Artificial reseeding on western mountain range lands. U.S.D.A. Circular 178.

W. G. Mann and S. B. Locke. History of the Kaibab deer. Mimeographed report.

In Outside publications:

Geo. Stewart and C. L. Forsling. Surface run-off and erosion control in relation to soil and plant cover on high grazing lands of central Utah. Jour. Am. Soc. Agronomy, Oct. 1931.

C. L. Forsling. Erosion on uncultivated lands in the Intermountain Region. Scientific Monthly, Apr. 1932.

ADMINISTRATIVE SECTION

ADMINISTRATIVE STUDIES

Forest Management

For several years the regular administrative organization of the region has been carrying on some studies work. It has been the plan to stick pretty close to method of cutting, method of thinning, and reproduction studies although it has been the policy to encourage any other line of studies which any individual desires to take up. At first the studies were started in ponderosa pine and the first permanent sample plots were established in this type. Several of the forests now have a very good series of method of cutting plots in ponderosa pine which will give excellent information concerning the rate of growth after cutting, mortality in the stand, and reproduction of the species on cut-over lands under present systems of cutting. During the past few years there has been a great increase in the amount of lodgepole pine which has been cut and an effort has been made to establish series of permanent sample plots in this type which will give the desired information concerning it when a sufficient period has elapsed to allow the accumulation of the record. There is a need for the same kind of plots in Douglas fir, Engelmann spruce and alpine fir as very few have been established in these types up to the present time.

The studies have branched out considerably from the original conception due to the fact that men have become interested in various phases of forest growth and have set out to find out what is actually going on by the establishment of plots and accurate measurements to take the place

of general observation. A number of plots have been established to study methods of brush disposal, the spread and possibility of eliminating mistletoe and beetle damage in the lodgepole pine type.

There are now on file data on 183 permanent sample plots, 72 of which are method of cutting plots, 40 method of thinning, 63 reproduction, six brush disposal, one mistletoe, and one beetle damage. This is exclusive of 16 additional method of cutting plots which have previously been reported as administrative study plots but which now have been definitely taken over by the Intermountain station for future observation. These are all on the Payette forest. The 183 plots are located on 21 forests so the studies work is widely distributed.

The year 1931 was one which did not lend itself to the carrying out of much studies work as insect control projects and fire required so much of the time of the regular forest personnel throughout the region that studies were pushed into the background and deferred. In consequence much projected studies work could not be done. However, 10 forests did some work on 42 plots in addition to carrying out such things as the construction of volume table, checking of volume tables, study of the accuracy of tree measurement sales, and in one case the study of defect and breakage on a large sale area. Clark Miles of the Payette forest was particularly active and during the course of the year he made up volume tables for Douglas fir and lowland white fir from measurements which he made on the Hallack & Howard sale near Cascade, Idaho. He also did some checking of the site volume tables for ponderosa pine on this sale and made a study

of the probable accuracy of tree measurement sales in the ponderosa pine type. He also carried out a very commendable study of defect and breakage on the Hallack & Howard sale area. A manuscript on this study has been mimeographed and sent to the ponderosa pine forests in Idaho and to several of the experiment station.

Nineteen forests have indicated a desire to carry out stated studies work during the year 1932. These projects cover the remeasurement of a number of permanent sample plots which have been established for five years, the establishment of several new plots covering method of cutting, method of thinning, damage to reproduction on cattle and sheep ranges, brush disposal, checking of volume tables, and compilation of volume tables.

Four forests have not been heard from yet as to their 1931 work done or their proposed work for 1932.

In studies work the Region is endeavoring to keep the personnel interested in forestry and the growth of trees which is the basis of forestry. This information increases interest in the work as well as knowledge of the principal resources of the forests. These studies result in the cumulation of much valuable information which better enables the carrying on of timber work and a better job of forest management.

Range Management and Game Studies

Plant collections, quadrat charting, enclosure construction, etc. were carried on during the year to a somewhat less extent than they have been in the past, due to increased work in emergency construction, insect control, and fire. Species plot work by the rangers is increasing and has proved a popular and effective way of checking on changes in the vegetative cover. About 150 have been established to date. The rangers have been encouraged to undertake individual studies of various kinds suited to local conditions and inclinations, and such studies have been initiated. For example, one ranger is reseeding depleted allotments with Bromus polyanthus seed grown and collected on nearby allotments, and is keeping records of costs and results. Another clipped one set of bluebell plants about June 20 for six years, resulting in a decrease in stems of 70 per cent, while another set of plants clipped about July 25 increased 262 per cent, and plants unclipped increased 2400 per cent. The same ranger is checking on the increase of red elder on his district by means of mapped plots. Another ranger found, from experiments, that green algae can be eliminated from water troughs by use of blue vitrol placed in small amounts in a glass container with a small opening, to prevent too rapid dissolution of the blue vitrol.

For a number of years the Region has observed the effectiveness of various kinds of materials, and various methods of construction used in water development projects with the result that rather definite ideas have been obtained as to proper standards, which appear in the latest revision of the RM section of the R-4 handbook.

A satisfactory system of coding plant development data for analysis recorded by R-4 rangers the past six years has been worked out and the work of coding is well advanced. It is hoped a complete analysis of the data can be made within the year.

During the year a carrying capacity study was initiated on the Humboldt National Forest of a fenced allotment of 7800 acres stocked with about 1375 cattle. Accurate use records are being kept and observations of changes in the vegetative cover will be checked by ten quadrats and species plots, and several fenced enclosures. A grazing survey was made of the area by both the ordinary and the volume-palatability methods. Utilization and palatability were carefully studied last season. A study is also being made of changes in vegetative cover under cattle grazing as compared to sheep grazing on an adjoining allotment.

Effectiveness of larkspur eradication by grubbing was investigated on several forests. It was found that on most projects the percentage of regrowth was too high, and the faulty practices responsible were called to the attention of the field. An experiment showed that eradication by chemicals is about 35 per cent cheaper than eradication by grubbing. This study is too limited to date to be conclusive, and the effectiveness of chemicals as compared to grubbing has not yet been fully worked out. A mattock type tool proved better for grubbing than a shovel.

A junior range examiner is making game studies on the Kaibab Forest following a detailed plan that should assist in solving a number of the most pressing problems. O. A. Olsen of the Regional Office, in cooperation with R. L. Turpin of the State Fish & Game Department, is making

a study of big game in Utah. Surveys of deer and elk numbers, migrations, foraging habits, economic status, etc. are being worked out on several of the congested areas in the State. It was found that an average of $35.00 is spent per deer hunter on the Beaver district of the Fishlake Forest. Counting elk from an airplane has proven a very successful, being more accurate, considerably quicker, cheaper and not requiring nearly as much manpower necessary to make counts by use of horses.

SUMMARY OF

FOREST MANAGEMENT

PROJECTS

RS-INF
Mc

March 1, 1932

Project: Methods of cutting and natural reproduction of ponderosa pine.

Scope: To determine the most satisfactory cutting policy from economic, silvicultural, reestablishment, and watershed standpoints of ponderosa pine as a reliable basis for management within the entire type in the region and more especially on granitic soils. To secure this result information must be obtained on cutting methods, total and net growth by tree and crown class, logging damage and brush disposal, the response of advanced reproduction and the germination survival and growth of subsequent reproduction.

Status: Comparatively early in the life of the Forest Service the importance of the ponderosa pine stands in southern Idaho was recognized and sample plots were established to determine advisable methods of cutting. Following this excellent start silvicultural research was suspended for several years. The project was revived in the F.Y. 1931. From the original work four cut-over, and sixteen virgin stand 5-acre plots have been salvaged and taken over in connection with this project.

Results 1931. These plots were remeasured in 1931, the present record now dating from 1911 to 1913 interspersed with measurements in 1918 on the virgin stand plots and 1918 and 1926 on the cut-over areas. Complete individual tree history was obtained and the records have been coded and are awaiting analysis on the Hollerith punch card machines.

Plans: Plans need to be flexible until plans for the season's cut have been decided by the timber operators in the ponderosa pine. Regardless of economic condition, indications are that sufficient logging will be done on national forests during the ensuing season to allow establishment of at least three series of plots that hold special merit at this time. These methods are as follows: an economic selection quality cut or high-grading the stand after the policies of some private operators; a heavy selection cut following Forest Service marking practice, and an unusually heavy diameter limit cut that would remove practically every merchantable log with the exception of a few in low quality thrifty trees. The work on these plots shall be most comprehensive, embracing every desired phase that is recommended by both Forest Service and private operators. It should include cost of logging studies. If circumstances will permit, additional methods of cutting will be incorporated.

Cooperation with private operators and the Regional office to secure uniformity in plot selection, measurement and analysis will be offered to the fullest extent to maintain and increase interest in administrative research.

At the close of the field season it is planned to complete the analysis of the available plot data and prepare a report on growth on cut-over plots and on virgin stands.

Assignment: C. A. Connaughton and E. L. Mowats.

RS-INT
Mc
(Plant Succession and Reproduction) March 1, 1932

Subproject: Plant succession following different methods of cutting and its effect on natural reproduction of ponderosa pine.

Scope: To determine the effect of plant succession of subordinate vegetation following cutting or natural removal of the timber stand on germination, establishment and growth of reproduction in the ponderosa pine stands of central Idaho. This study will also include the effect of both grazing and fire on succession and reproduction.

Status: Opening the timber stand is followed by changes in subordinate vegetation which more or less influences the establishment and growth of forest reproduction. Work was initiated on this subproject in 1931 coincident with other work.

Results: Records were made of the composition and density of the vegetative cover under standing and dead timber in virgin stands and on cut-over land. General methods devised preparatory to further procedure.

Plans: The vegetative cover on cut-over areas of varying ages on both private and national forest land is to be studied. Areas will be selected under different degrees and ages of cutting, of grazing and of burning. The vegetation on each will be studied by transects radiating from trees or stumps, on which the subordinate vegetation and reproduction will be closely charted in an attempt to relate presence and vigor of natural reproduction to plant cover and degree of succession. By use of old cuttings handled under different silvicultural systems results can be realized at an early date and treatment in regard to the vegetative cover recommended.

Cooperation: Floyd Otter of the University of Idaho.

Assignment: C. A. Connaughton and Floyd Otter, instructor, University of Idaho.

RS-INT
Mc
(Snow Storage and Recession) March 1, 1932

Subproject: The effect of varying quality and character of forest cover as may result from different methods of cutting on the depth and water content of the total accumulated winter snow and its rate of melting.

Scope: To determine the effect of the character and degree of ground and crown cover on the empirical watershed value of the ponderosa pine stands of central Idaho, by measuring the amount, water content and rate of melting of the total accumulated winter snowfall under each cover condition represented. Complete record is being obtained of the winter snowfall, its water content and rate of melting under the different densities of crown and ground cover. Melting records are supplemented with measurements of air and soil temperatures, soil moisture, wind velocity, sunshine duration and precipitation during the melting period.

Status: The project was initiated in the spring of 1930 as a result of serious objections raised by irrigators to the prevailing methods of cutting ponderosa pine with regard to its effect on streamflow. Two plots of varying densities of ground and crown cover were first studied in the Boise Basin. Five new plots were chosen on the Idaho National Forest at McCall, Idaho in 1931. The following ground and crown covers are represented: a typical overmature, clean-floored ponderosa pine stand, an overmature ponderosa pine stand with a dense understory of 30-year old reproduction, a stand of 30-year old reproduction, a dense stand of sagebrush, and bare gound. A total of 125 snow measurements are represented on these plots in addition to ten supplemental snow survey courses.

Results in 1931: Preliminary data show that a maximum amount of snow storage is favored by a minimum forest cover and that the rate of snow melting is retarded by forest cover. Considering the greatest snow cover of 10 inches water content on the sagebrush plot as 100 per cent, snow under the other conditions were as follows: bare ground 99.5 per cent; young growth 87.5 per cent; mature-timber-without-undercover 72.5 per cent; and mature-timber-with-advance-reproduction 63.5 per cent. The sagebrush and bare plots became bare first - 25 days after maximum snow accumulation, and the mature-timber-with-advance-reproduction became bare last - 10 days later.

Plans: Regular measurements and mapping of the spring snow recession will be continued each year until such a variety of climatic factors are incorporated that definite results can be obtained and published.

Assignment: C. A. Connaughton.

SUMMARY OF

RANGE MANAGEMENT

PROJECTS

RR-INT
Management
Summer Range (Wasatch Plateau)
(Climate and Plant Growth) March 1, 1932

Subproject: The effect of climate on plant growth.

Scope: To determine for mountain summer range (1) which of the more common climatic factors are of primary importance to forage growth, and (2) the part climate, and particularly the fluctuations in climate from year to year, play in (a) forage development and production, (b) the outcome of experimental work generally, and (3) the adjustments in range management necessary to meet fluctuations in forage production.

Status: Vicissitudes of climate play an important role in range management. Records of the more important climatic factors have been kept during the growing season continuously since 1914, and in some cases year long, in three vegetative zones on the Wasatch Plateau in Utah. Forage yield and time and rate of growth have been observed since 1924 to correlate plant growth and forage yield with the climatic factors. Results to date show temperature chiefly influences start and rate of growth in the spring, that subsequent precipitation during the main growing period is the most critical factor that affects forage production and that the extra quantity of forage in the wetter seasons is offset to some extent by poorer quality.

Results in 1931: Precipitation during the 1931 main growing period was among the lowest of record and was chiefly responsible for the forage yield being 40 per cent below the 8-year average. Range on which there had been no adjustments in grazing in 1931 began appreciably to show the effects of five dry seasons in the last 8 years.

Plans: Observations on the climatic factors and forage yield will be continued during 1932 and until a complete rainfall cycle has been covered. The data obtained to and including 1931 is ready for summarization and report and will be pushed during the F.Y. 1933.

Assignment: E. W. Nelson and R. Price.

RR-INT
Management
Summer Range (Wasatch Plateau)
(Natural Revegetation)

March 1, 1932

Subproject: Range improvement and maintenance by natural revegetation of native forage species on summer range lands.

Scope: To determine (1) the most expedient and economical method of natural revegetation of native forage plants, (2) the rate of reestablishment of valuable forage plants on depleted range lands, and (3) methods of management of livestock on the range to meet the requirements of the native forage plants for natural revegetation and at the same time meet the feed requirements of the livestock to the fullest degree possible.

Status: Seventy-two quadrats, 69 major plots, and 5 intensively mapped areas have been established since 1914 and recorded at regular intervals to determine the improvement and change of the native forage cover on mountain range lands on the Wasatch Plateau in central Utah under conditions varying from destruction of the vegetation and heavy erosion of the soil, to approximately normal stands and under several conditions of grazing. Early results up to 1922 were published in Department of Agriculture Bulletins 791 and 1405.

Results in 1931: The quadrats and major plots in the oakbrush and aspen-fir zones and a few in the spruce-fir zone constituting about one-half of the total number, were either charted or listed. The second 5-year detailed mapping of four browse plots in the oak brush zone was completed.

The study of the physical and some of the chemical aspects of the soil was started in 1931 with the collection of 33 samples from various protected areas at different elevations. These samples are being analyzed during the winter.

Plans: Quadrats, major plots, and the larger intensively mapped areas not mapped in 1931 will be remapped in 1932 as called for in the regular plan. Sufficient data are accumulated for the preparation of an additional progress report. The detailed study on several additional factors, including the chemical, physical, and biological aspects of the soil in relation to the growth and establishment of vegetation will be continued in a limited way during the year.

Assignment: E. W. Nelson and R. Price.

RR-INT
Management
Summer Range (Wasatch Plateau)
(Degree of Utilization)

March 1, 1932

Subproject: The proper degree of utilization.

Scope: To determine (1) proper degree of utilization, (2) standards for judging utilization, and (3) percentage of good forage which should remain at time of seed maturity each year on ranges where deferred and rotation grazing is not applied to improve or maintain the forage stand.

Status: A pasture with hurdle plots and quadrats arranged in a manner as to secure varying degrees of utilization of the important range plants each year, constructed in 1923 on the high summer range, has been grazed by a small herd of cattle each season since 1925.

Results in 1931: The pasture was grazed and utilization records were obtained. Plants of Stipa lettermanii that had been utilized to different degrees were collected after the cessation of growth in 1931 and analyzed for carbohydrates. Utilization of collected plants varied from 0 to 62.5 per cent. There was no correlation between carbohydrates and degree of utilization.

Plans, F.Y. 1933: The pasture and the various hurdle plots will be grazed in accordance with the plan of the project, the major plots and quadrats will be remeasured and if possible, further studies will be made of carbohydrate relationships.

Assignment: E. W. Nelson, R. Price.

RB-INT
Management
Summer Range (Wasatch Plateau)
(Periods)

March 1, 1932

Subproject: Vegetational readiness and the length of the grazing season on summer range.

Scope: To determine (1) the effect of continued early use on the vigor and production of range forage plants, (2) the time at which stock may be admitted to the range without injury to the forage from too early use, (3) methods of determining the time of range readiness, (4) the effect of close cropping of the vegetation in the fall after seed maturity, and (5) the time that grazing should be discontinued in the fall.

Status: Results prior to 1923 setting forth the effect of early clipping on subsequent production during the year, the stage of development that will withstand moderate grazing and a method of judging range readiness on the basis of the development of different groups of plants, and handling stock on the range in accordance with proper seasonal use on the Wasatch Plateau published in Department Bulletin 1405.

Since 1925 a systematic study has been made of the important range plants at varying elevations to determine the variation in vegetational development (phenology) from year to year. Detailed growth records of individual plants of important forage species have been obtained from the beginning of growth in the early spring and extending throughout the season until covered with snow in the fall.

Results, 1931: Plant development records were continued through the season.

A preliminary analysis of results of grazing in the oakbrush zone indicate that if grazing starts 10 to 14 days before vegetational readiness there is a decline of approximately 25 per cent in carrying capacity over a period of eight years. There was an improvement in carrying capacity of 39 per cent when grazing was delayed until vegetational readiness.

The records will be analyzed for publication in 1932.

Plans, F.Y. 1933: Field work has been completed except for a few key stations. The results of eight years observation are ready for analysis.

Assignment: E. W. Nelson, R. Price.

RR-INT
Management
Summer Range
(Season, Frequency, and Degree of
Harvesting)

March 1, 1932

Subproject: The relation of season, frequency, and degree of harvesting to the productivity, revegetation and vigor of the vegetation.

Scope: To determine the effect on vigor, revegetation and productivity of harvesting at different seasons, intervals, and closeness of cropping on important forage species growing on mountain summer range and to work out methods of grazing based on the results to improve and maintain the range, and at the same time obtain the best use of the forage.

Status: The main results of early work, involving eleven species and 26 methods of harvesting, are reported on inDepartment Bulletin 1405. The project was revised in 1923 to study more critically some of the methods previously tried out, on a plot rather than individual plant basis supplemented with actual grazing trials. The clipping and grazing field work, except for the browse species, is completed and awaiting analysis. Two important browse species were added to the clipping study in 1926 and were supplemented with hurdle plots.

Plans, F.Y. 1933: To analyze for publication as soon as possible all available data and to continue the tests with shrubs for several years longer.

A further study to determine the influence of frequency in harvesting upon the carbohydrate metabolism of Agropyron violaceum, Bromus polyanthus and Geranium viscosissimum in cooperation with Dr. E. C. McCarty of Riverside Junior College, Riverside, California, will be started during 1932 and to be continued through 1933 and 1934.

Assignment: E. W. Nelson, R. Price.

RR-INT
Management
Summer Range (Wasatch Plateau) March 1, 1932

Subproject: The role of seeding habits of range plants in natural revegetation.

Scope: To determine the influence of seed production and germination as a factor in the natural revegetation of range lands.

Status: Seeding habits, seed production, seed dissemination and germination under various conditions of storage, temperature and moisture relationships for 55 important range species have been determined for four seasons.

Results, 1931: Results were computed and analyzed.

Plans, F.Y. 1933: Complete report.

Assignment: C. L. Forsling.

RR-INT
Management (Wasatch Plateau)
Cell-Sap Characteristics

March 1, 1932

Project: Characteristics of the cell sap of range plants in relation to environment and grazing use.

Transferred to Management, Desert-Shrub Range project.

RR-INT
Management
Bunchgrass-Granitic Soil

March 1, 1932

(Formerly included in the erosion-streamflow project statement.)

Project: The management of the bunchgrass-granitic soil type.

Scope: To determine the methods of range management of the bunchgrass-granitic soil type on watershed lands.

Status: The coarse granitic soils of the important watershed lands in Idaho are easily susceptible to trampling and erosion, thus requiring special care in management to maintain forage productivity, avoid erosion and loss of the surface soil, and not interfere with streamflow. The project was started in 1930 in conjunction with the erosion-streamflow study.

Results, 1931: Eleven areas, 0.1 to 200 acres in area, have been selected and fenced to exclude livestock; one hundred 5x5 meter major plots and 95 meter quadrats were established under different conditions of grazed and ungrazed range. One hundred seventy soil samples have been collected and analyzed for important chemical and physical properties.

Three important stages or conditions are found to be represented: First, a nearly normal condition of abundant perennial cover, with a soil high in organic matter and plant food and a good water-holding capacity, the phase that formerly prevailed over much of the type; second, a recently depleted and eroded condition of coarse rooted perennial weeds and grasses and many annuals, a coarse soil, low in organic matter, and of poor water-holding capacity; and, third, an older eroded phase where downy brome predominates, with a coarse soil and low organic content, but somewhat higher in water-holding capacity than the second phase, owing apparently, to a new litter of decaying downy bromegrass.

An improved method of measuring vegetation in plot work was perfected and described for publication.

Plans, F.Y. 1933: To make annual remeasurement of selected key plots and quadrats for correlation with climate, start an investigation of root systems of important species in relation to adaptability to site and value for erosion control, to establish a few more plots and quadrats as needed and to prepare for publication a report on the three stages or phases now to be found in the type.

Assignment: G. W. Craddock, Jr., and C. Kenneth Pearse.

RR-INT
Management
(Sagebrush-Bunchgrass) March 1, 1932

Project: The management of sagebrush-wheatgrass range.

Scope: To determine methods of range management to improve and maintain the native forage crop on sagebrush-bunchgrass range and develop its best use for range sheep and cattle production in the Intermountain region.

Status: The sagebrush-wheatgrass ranges of the region are thus far recognized to fall into three major subdivisions: sagebrush-wheatgrass foothills of Utah; the sagebrush-bunchgrass-giant ryegrass areas of northeastern Nevada and the Snake river and adjacent foothills in Idaho. All of these subdivisions are in heavy demand for spring and fall grazing and for the most part are now far below potential productivity as the consequence of injudicious use in the past. They have become the "neck-of-the-bottle" in range livestock production. A study to develop improved methods of management of these ranges, exclusive of the Upper Snake River plains, was started in F.Y. 1930. A study of the effects on vegetation of past use and fire was carried through 1930 and summarized for publication.

Results, 1931: Eight enclosures were established to study rate of natural revegetation. A survey of sheep production in relation to area and condition of spring-fall range shows that a scarcity of this range results in poor growth of lambs during May and June, practically precluding early lambing and results in the production of fall "feeder" lambs as compared to the production of "killer" lambs where there is more ample spring range.

A survey indicates mineral deficiency, particularly phosphorus, causing malnutrition of range cattle on parts of the sagebrush-bunchgrass range in northeastern Nevada.

Plans, F.Y. 1933: To continue accumulation of data on changes in original plant cover and grazing capacity whenever significant areas are found; to continue study of influence of spring-fall range on sheep production and to extend the study to cattle ranges; to establish natural revegetation plots; to begin controlled grazing studies if a satisfactory pasture is available; to begin compilation of data on palatability and utilization of important species; study relation of weather to plant growth, to begin exploratory ecological studies and to complete analysis and report on cell-sap studies of mountain, foothill and desert vegetation (Harris data.)

Assignment: George Stewart, G. D. Pickford.

RR-INT
Management
(Sagebrush-Bunchgrass Range U.S.S.E.S.) March 1, 1932.

Subproject: The management of sagebrush-wheatgrass range (Upper Snake River plains, at U.S. Sheep Experiment Station).

Status: In consideration of the importance of the range factor in sheep production, range management studies were undertaken in 1923 in cooperation with the Bureau of Animal Industry at the U.S. Sheep Experiment Station on the Upper Snake River plains in Idaho. To date the study has included the influence of yearly climate on forage growth and production and on sheep production; the influence of four systems of spring grazing, yearly deferred grazing, continuous spring, summer and fall grazing on range productivity; and carrying capacity on herded range.

Results, 1931: The systems of use and other studies as planned were carried through their eighth year. The original draft of a manuscript for publication is nearing completion. Phenological, quadrat and grazing records show that start of plant growth may vary as much as 35 days, height growth may vary 44 per cent and forage production over 100 per cent one year with another. Climatic records show the last 14 years have been a period of drought and were preceded by 10 years of more than average growing conditions. The record at Boise, Idaho, shows there have been four dry periods and four "wet" periods in the 63 years last past.

Plans, F.Y. 1933: To complete the manuscript for publication; to start a test in four new paddocks of a system of deferred and rotation of early grazing, and to start a study of methods of rehabilitating depleted range.

Cooperation: U. S. Sheep Experiment Station of the Bureau of Animal Industry.

Assignment: George Stewart, G. D. Pickford (G.W. Craddock, pending completion of manuscript and J. M. Cooper of the U.S.S.E.S.).

AR-INT
Management
Desert Shrub Range

March 1, 1932

Project: The management of desert-shrub range.

Scope: To determine, experimentally, the methods of management which will restore and maintain the grazing productivity and promote its best use, of desert-shrub winter ranges. This involves the character, distribution, forage value, growth requirements, and reaction to grazing of the native vegetation.

Status: The project was started in the fall of 1930. There is but meager specific information on the past or present condition of this type of range, necessitating preliminary explorations and accumulation of data on this extremely important grazing area of the region which users report has declined 50 per cent or more in productivity. The preliminary survey and segregation of broad subdivisions is well under way. The general broad subdivisions thus far recognized are: Owyhee Desert of southwestern Idaho; southeastern Wyoming; "East Desert" of Utah; "West Desert" of Utah and adjacent Nevada, and south central Nevada.

Results, 1931: The more important type species have been determined, prospective sites for an experimental range tentatively selected; studies of type subdivisions started; plant growth measurement stations established and palatability utilization studies gotten under way, and two weather stations established.

Plans, F.Y. 1933: Plans for the year contemplate final selection of the experimental rage, completion of project working plans, continuation of palatability and utilization studies, starting of natural revegetation studies, making of herding method observations, establish phenology stations and make further preliminary observations of soil, drainage, climate and other ecological agencies on growth and development of desert range species.

Assignment: George Stewart, S. S. Hutchings.

RR-INT
Management
Browse Range

March 1, 1932

Project: The management of browse range.

Status: Early work completed and published. Project now temporarily suspended. A pasture of 178 acres of browse range on Dixie National Forest being held ungrazed for possible future use.

RR
Exhibits and Illustrative Material March 1, 1932

Project: Cooperation in the preparation of exhibits and illustrative material for educational purposes.

Discontinued as a separate project.

RR-INT
Artificial Reseeding March 1, 1932

Project: Artificial reseeding of depleted mountain summer range lands.

Scope: To determine (1) suitable species, (2) site conditions, (3) methods and time of seeding, (4) seed production, (5) methods of grazing during periods of establishment, and (6) economics of improving depleted range by introduction of tame (cultivated) and native forage species on mountain ranges in central Utah where the annual precipitation is from 18 to 30 inches, and the growing season 100 to 120 days in length.

Status: Artificial reseeding trials were started as early as 1910 on the Wasatch Plateau in Utah and have continued since then. These trials have been on a small scale and of an empirical nature. A large number of forage species have been tried out at different elevations under various soil conditions, moisture, time of seeding, and treatment. The results of the work up to 1927 were published in 1931 in Department Circular 178.

Since 1925 practically all of the artificial reseeding tests have been in the oakbrush zone where the main growing season extends from May 1 to August 31. The sweet clovers, crested wheatgrass, common brome, violet wheatgrass and many-flowered brome were used in most of the tests. These tests involved various methods of tilling the land and covering the seed, and the time of sowing.

Results, 1931: Tests in 1931 consisted of replications of former sowings except that seeding on the snow was added. Crested wheatgrass and common brome establish themselves readily in heavy sagebrush stands, produce abundant forage and mature seed crops on range up to an elevation of 8000 feet. These grasses sown in 1929 in plowed contour furrows and covered with a brush harrow on an ungrazed range had by 1931 increased the carrying capacity approximately 40 per cent. Seed ofcrested wheatgrass sown broadcast on the raw ground and then trampled in with sheep followed by no livestock grazing, increased the carrying capacity of the range approximately 23 per cent; but with common brome there was no increase; only slight increases in carrying capacity occurred where the seed was sown broadcast on raw ground with no treatment. Yellow sweet clover produced excellent forage crops where protected from livestock and rodent grazing, and in places there was good natural reseeding; seed sown in 1929 under protection in plowed contour furrows and then covered with a brush harrow increased the carrying capacity of the range in 1931 from 33 to 38 per cent.

Plantation sowings in 1929 in heavy sagebrush at 8000 feet elevation with A. violaceum and B. polyanthus in plowed furrows and then covered with a brush harrow showed an increase in carrying capacity of 46 per cent in 1931. The sowing of B. polyanthus broadcast on the raw ground without any further treatment or with the seed trampled in with sheep, resulted in failures.

Nursery tests were continued in 1931 with seed of native species collected on the Manti National Forest and with seed collected in Region 5. A total of 49 seed samples of seven native grasses, two tame grasses, three native weeds, and one native shrub were collected in the various vegetative zones near the Great Basin Branch Station.

Plans, F.Y. 1933: Examinations of results from former sowings will be continued but no new tests will be started.

Cooperation: Bureau of Plant Industry on tests with sweet clovers, crested wheatgrass and common brome.

Assignment: E. W. Nelson, R. Price, (L. W. Kephart of Bureau of Plant Industry.).

SUMMARY OF

EROSION-STREAMFLOW

PROJECTS

R - INT
Erosion and Streamflow
Bunchgrass Type on Granitic Soils March 1, 1932

Project: The influence of plant cover and its use in the bunchgrass type on granitic soils on erosion and streamflow.

Scope: To determine, for watersheds of the bunchgrass type on loose granite soils: (1) the causes of erosion; (2) the rate of erosion; (3) the influence of herbaceous cover as influenced by grazing use in controlling erosion and regulating run-off; (4) methods of checking and controlling erosion and maintaining desirable run-off conditions by natural and artificial revegetation and other means. It involves the investigation of all the factors in which plant cover plays a part, that affect the yield and rate of discharge of water from a watershed and the erosion of the soil as a means of determining the amount, kind and regulation of cover that will obtain desirable streamflow and control erosion.

Status: A range erosion-survey has been made of 371,000 acres of watershed land to isolate the various physiographic and biotic factors which contribute to erosion. A series of profiles, to be checked at regular intervals have been established to measure rate of gully enlargement and sheet erosion. Nearly 200 soil samples have been collected and analyzed to show influence of past erosion on important physical and chemical properties of the soil. Preliminary observations are under way to compare degree of erosion from melting snow and from summer rainfall.

Results: An analysis of soil samples strongly indicates that the surface layer of the better top soil has been eroded away in the bunchgrass type over a large part of the watershed. The present top layer of soil over widespread areas conforms to the second, or 10 to 20 inch horizon of profiles examined on a few protected uneroded sites. On extremely eroded situations the top layer conforms to the third, or 20 to 30 inch horizon, of the best sites. The soils of the uneroded sites, have approximately 10 per cent organic material and 0.45 per cent nitrogen in the surface eight inches, and are dominated by a bunchgrass association in which A. spicatum is most prominent. On the more eroded sites, the organic content measures only 2 per cent and the nitrogen approximates only 0.15 per cent and the climax vegetation has been displaced by more xeric species and by annual weeds and grasses particularly. The root systems of the xeric species trend toward the tap root form, poor for soil holding purposes as compared to fibrous and generalized root systems highly capable of holding the soil, in the climax group.

Recheck surveys of several of the gully sections indicated that steep banks, in the last two years, have broken down to widen the gullies

but otherwise little additional gullying has occurred. Changes on the sheet erosion plots were insignificant.

The range-erosion survey data show that the factor of accessibility or use by livestock gives the highest direct correlation with erosion. Slopes up to 30 per cent likewise showed a high correlation but on steeper areas no relationship was indicated.

Plans, F.Y. 1933: To measure surface run-off and erosion on temporary plots representing different conditions of slope, cover and soil with special equipment designed to reproduce various conditions of rainfall: to install equipment to measure run-off and erosion from melting snow from permanent sample plots, and to measure interception and loss of moisture supply through evaporation and transpiration with small lysimeters and lysiphytometers.

Assignment: C. L. Forsling, G. W. Craddock, C. K. Pearse.

R - INT
Erosion & Streamflow
Utah Flood & Erosion Survey

March 1, 1932.

Project: A survey of recent floods and accelerated erosion in Utah.

Scope: A survey of land areas and drainage systems in the State of Utah which have been the scene of recent excessive floods and abnormal erosion or arepotential sourcesof such, for the purpose of determining (1) the nature and extent of occurrence of abnormal floods and erosion; (2) the apparent contributory causes of abnormal floods and erosion; (3) the possible means of their prevention and control; (4) what further detailed research is advisable for the eventual solution of the watershed protection problem of the state.

Status: Excessive floods accompanied by heavy erosion of the soil occurred in many localities throughout Utah during the summer of 1930; similar floods have occurred in previous years, notably in 1923 and 1927, and lesser ones have been recorded as far back as 1877. Upwards of a million dollars worth of damage to highways, railroads, and rural and urban property was caused by floods within the state in 1930, and the aggregate losses over a period of years have run into several millions of dollars, in addition to the loss of several lives.

In 1923 a survey of the flood areas in Willard and Farmington Canyons was made, the findings of which were published in Bulletin of University of Utah. vol. XV, no. 3, "The Floods of 1923 in Northern Utah." In 1930 a more intensive survey was made of the flood areas in Davis county (the area centering about Farmington), the findings of which were published in Circular no. 92, Utah Agricultural Experiment Station, "Torrential Floods in Northern Utah, 1930." In 1931 the field work of a rather intensive survey of all past and potential flood areas on record in the state was donducted.

Results, 1931: Observations generally indicate that depletion or natural sparseness of plant cover or both, on critical areas on watersheds of drainage is apparently the chief contributory cause of excessive erosion and flooding in Utah. There is a need for further localized experimental work to determine the relative influences of various types of plant cover, soils, geological formations, and climatic factors on Utah flood areas. On certain areas the role of artificial revegetation and of engineering structures in watershed protection and flood control should be further investigated. There is urgent need for the development of a land management policy which will regulate grazing use on both public and private lands where these are so situated on watersheds as to materially influence the condition and use of arable lands below them.

Plans: It is expected to complete the analysis and correlation of records secured during the field examination, secure records of land ownership and local climatic records, and prepare a report of the findings by June 30, 1932. It is very probable that publishing of the report will not be accomplished until after that date.

Cooperation: The Utah State Land Board, and the Utah State Agricultural Experiment Station.

Assignment: C. L. Forsling, Milo H. Deming.
Reed W. Bailey, Ray J. Becraft, collaborators for state of Utah.

R - INT
Special
Erosion & Streamflow
Colorado River Watershed Survey

March 1, 1932

Project: Colorado River Watershed Erosion Survey.

Scope: An extensive survey of conditions contributing to erosion in the Upper Basin of the Colorado River watershed in Utah, Wyoming and Colorado, for the purpose of gaining definite information with regard to the character and extent of soil erosion occurring, and its apparent relation to silting of streams, to the depletion of surface soils, and to various phases of human occupancy and resource development in the Colorado River basin and to determine the need for detailed or localized research as to causes of erosion and possible means of prevention.

Status: The watershed of the Colorado River in Utah, Wyoming and Colorado is an area of 98,000 square miles characterized by wide extremes of variation in elevation, temperature, precipitation, soil, and character and distribution of vegetation.

Prior to the field examination conducted in 1931 no systematic attempt has been made to secure definite information on erosion conditions, although numerous scattered observations have been made by various workers engaged in different phases of development of the natural resources of the region.

Results, 1931: Since settlement, erosion has been accelerated on the lowlands and to some extent on the uplands to a degree far beyond that which occurred through periods for a long time previous. Frequently recurring floods, increasing silt load of streams, increasing gullying and arroyo-cutting in valleys, and rapid entrenchment of stream channels in former flood plains are evidence of this trend. Results of the observations made show the area to be 50 per cent seriously eroding, 27 per cent moderately eroding, and 23 per cent lightly eroding. Most active and serious erosion is occurring at lower or medium elevations where there are semiarid conditions, soils of sedimentary origin, and a natural sparse plant cover which has been subjected to extreme grazing use. In places the vegetation on the uplands has been depleted and there appears to be coincident accelerated erosion. That erosion has been greatly amplified since settlement is evident. Excessive erosion and floods are adversely affecting range, irrigation, and power use and development in the entire Colorado river region.

Plans, F.Y. 1933: To prepare a more detailed report of the 1931 field survey which will include findings on all the areas examined and to make a field examination of a few additional areas not examined last season in the Fremont, Escalante, and Paria drainages in southern Utah. Most of this above work should be completed during the period to June 30, 1932.

Assignment: C. L. Forsling, Milo H. Deming.
Jay Higgins - Region 2.

R - INT
Biological Investigations March 1, 1932.

Project: Forest and range biology.

Scope: To determine the role of rodents in (1) erosion of the soil and in surface run-off on granitic soils, and (2) in natural revegetation and artificial reseeding of range lands; and to study life habits, food requirements and other factors essential to the management of deer on range lands used in common by game and livestock and on exclusive deer range.

Status: An associate biologist was assigned to the station by the Biological Survey in 1930. He began studies on the role of rodents in erosion on granitic soils and in revegetation of range lands and continued studies in cooperation with the regional office on which he had been previously engaged.

Results, 1931: Five rodent-proof enclosures were established and approximately 20,000 acres were treated to control ground squirrels and pocket gophers on watersheds with granitic soils. Four rodent-proof enclosures were established on the Manti Forest for a study of rodents in relation to revegetation. Life history and habits of pocket gophers were studied.

Plans, F.Y. 1933: Indefinite until vacancy in biologist position is filled.

Assignement: (In cooperation with Biological Survey)_____(vacant).